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UNIVERSITY OF ARKANSAS

RESEARCH FRONTIERS

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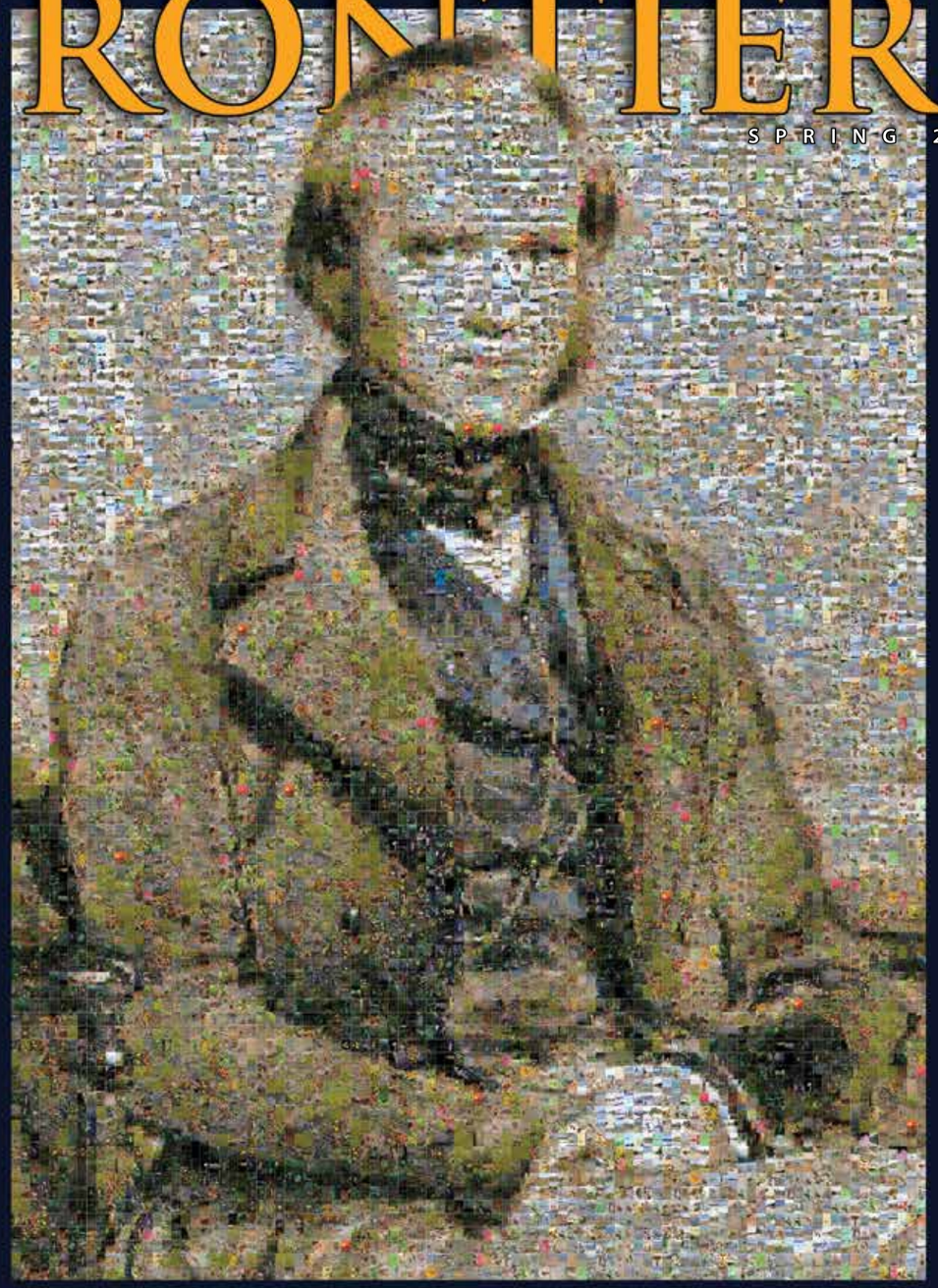


Darwin's Legacy

Peter Ungar
Professor of Anthropology

"How stupid of me not to have thought of it", Thomas Henry Huxley is reported to have said upon learning of Charles Darwin's and Alfred Wallace's theory of natural selection. The idea was so simple, so obvious, and so elegant. Individuals within a species vary, and that variation can be passed between generations. Those with favorable traits will survive longer and produce more offspring than those with less favorable ones. Over time, species will evolve traits to improve their "fit" in a given environment. This is the foundation of the most profound law in all of biology, and it explains all of the diversity of life on this planet and its likely descent from a single common ancestor.

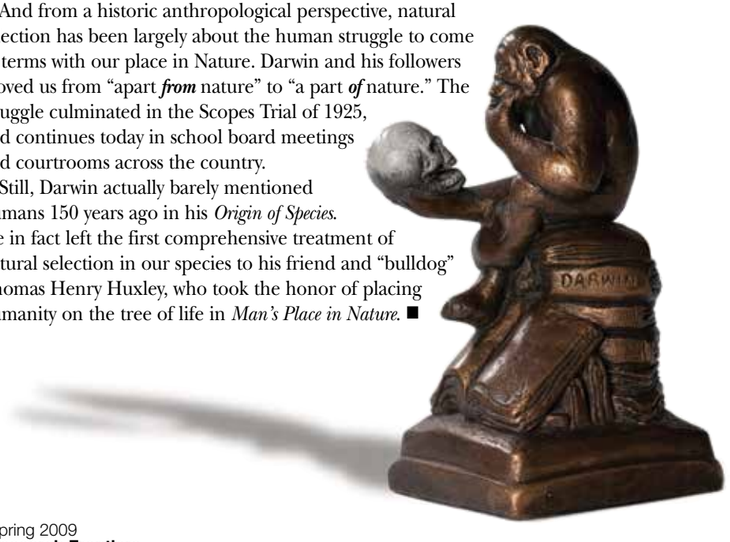
But if natural selection seems intuitive to us today, why didn't Huxley or any of the legions of naturalists that came before him think of it? Aristotle believed that biological species were real and unchanging entities with fundamental essences, and that variation between individuals was simply imperfection in translation to the world around us. The brilliance of Darwin and Wallace was not the idea of natural selection per se, but rather, the rejection of long-held notions of essentialism, and the recognition that variation was not imperfection, but rather, the key to unlocking the fundamental organizing principle of all living things on Earth.

Darwin's influence on the natural sciences has been profound, and his ideas remain fundamental guiding principles for research in many disciplines. Natural selection today underlies studies in the life sciences ranging from medicine to nutritional ecology, biodiversity, and conservation issues. This issue of *Research Frontiers* contains examples of research from the University of Arkansas, and similar work is being done today on campuses the world over.

Even the arts and humanities have been touched by Darwin's legacy. Natural selection theory was soon applied to the question "why do we have minds," and used as a radical critique of the notions of progress. These ideas quickly filtered into literature, and authors such as H.G. Wells explored the implications of human evolution in their fictional narratives. Of course, Darwinism has also been misused, with considerable but tragic effects, such as the Nazi eugenics movement and associated social Darwinism.

And from a historic anthropological perspective, natural selection has been largely about the human struggle to come to terms with our place in Nature. Darwin and his followers moved us from "apart ***from*** nature" to "a part ***of*** nature." The struggle culminated in the Scopes Trial of 1925, and continues today in school board meetings and courtrooms across the country.

Still, Darwin actually barely mentioned humans 150 years ago in his *Origin of Species*. He in fact left the first comprehensive treatment of natural selection in our species to his friend and "bulldog" Thomas Henry Huxley, who took the honor of placing humanity on the tree of life in *Man's Place in Nature*. ■



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Capturing the Ordinary Layer by Layer

By Barbara Jaquish

Laura Terry lives and paints on a wooded hillside in the Ozarks. Just half an hour away at the University of Arkansas, she introduces architecture students to the art of developing and conveying their design ideas through hand rendering. Before students learn to communicate design concepts via computer, they learn "to use drawing as a way of thinking," a skill that she is convinced makes them better designers.

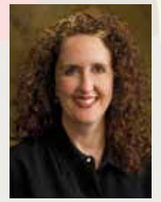
"I absolutely believe that when a student is able to capture things like material quality, texture, light, weathering, time, shadow, then they have a better understanding of the building," Terry said. "And they are better able to make smart design decisions."

Once students have learned "to trust what they are seeing and to trust their ability to put it on paper," Terry said, they are freed to use the computer as simply a tool.

Back in her own studio, Terry says her work "borrows structure from my study of architecture." The way she paints is akin to an architectural process, "an additive and subtractive way of working that is something we encourage with our students." After one layer of paint dries, she adds another and later another. Then, using a palm sander, she removes layers to expose previous layers. By this method, the first layer may become prominent in the final work.

In an essay in *Overland Review, The Journal of the Center for Arkansas and Regional Studies*, she described her process as one that creates a residue of evidence of the artist's struggle:

"The paint preserves information that is unique to each layer applied, and those layers build to create a textured surface, filled with mistakes, chances and edits. The resolution of the surface is unpredictable – it is not planned from the inception, rather revealed through layering and removing."



As a landscape painter, Terry tries to "capture things that are so ordinary that they often are overlooked." Her rural home offers a window on the cycle of nature. During the summer, she watches butterflies swarm the purple thistles that line her lane. In winter, the thistle seeds sustain birds. Often, the thistles and the fields of swaying golden grasses are the only realistic elements in otherwise abstract work that explores the horizontal and vertical lines of the landscape.

Just as Terry asks her students to break away from the comfortable, familiar world of computers, she asks herself to break away from familiar patterns in her own painting:

"Some things become a habit. I've been working almost exclusively in a square format. I realized that's gotten a bit easy, and I'm using the same tricks to create the composition. So for my next series of paintings I'm moving to a rectangular format. I don't want the shape to be a crutch. I want to use a square composition because it needs to be square, not because it's what I'm used to. These are the ways we remain critical of our own work." ■

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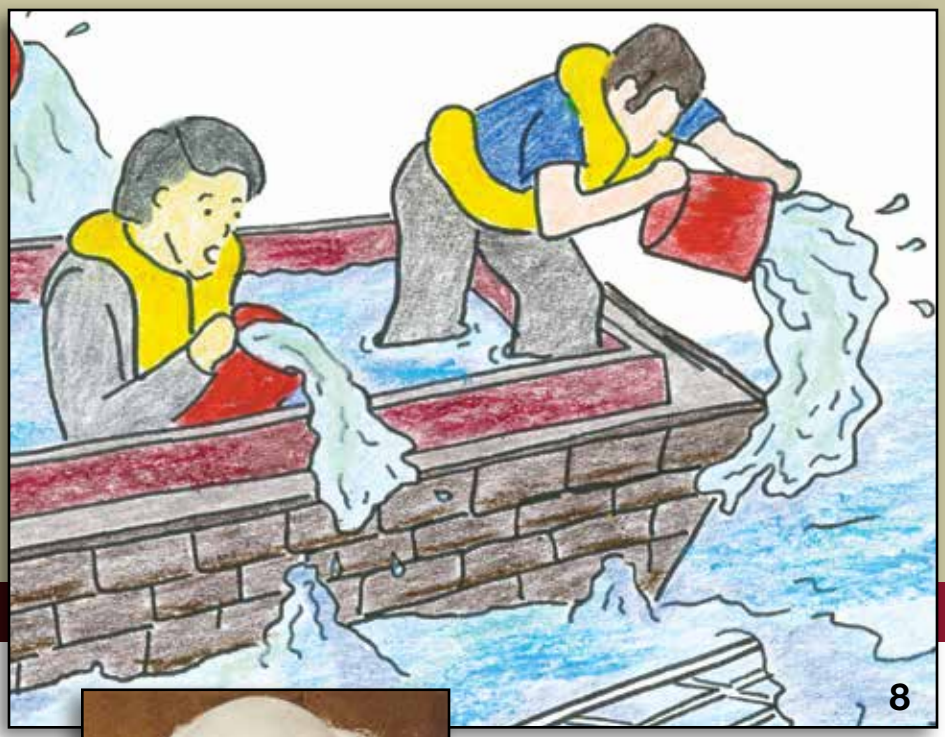

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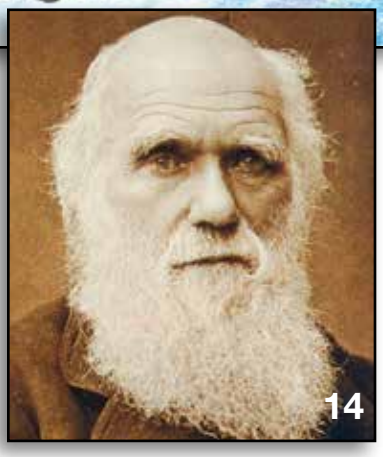

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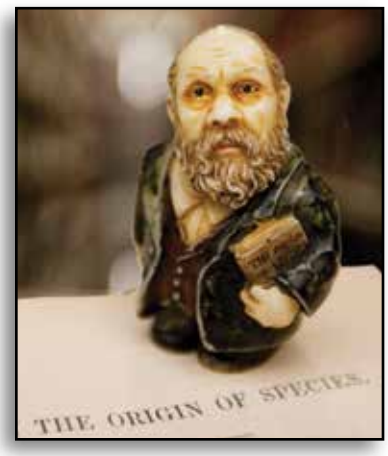

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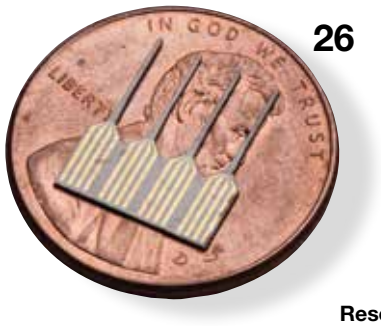
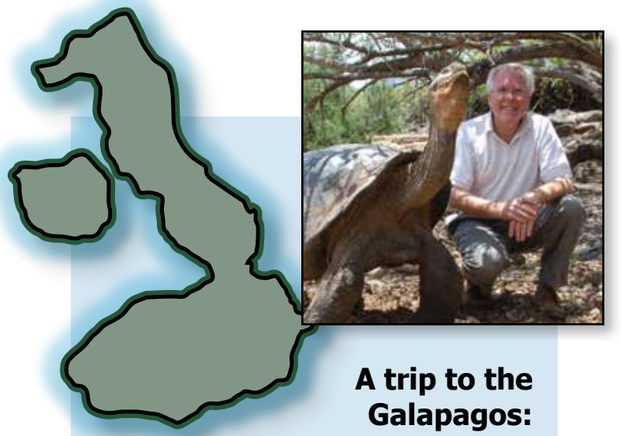


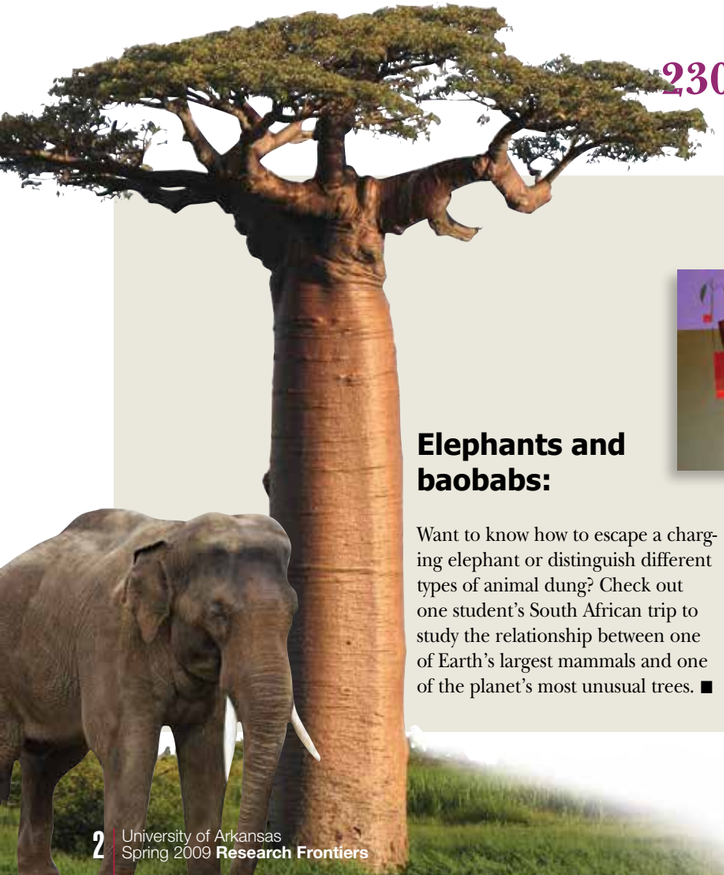


A trip to the Galapagos:

Science educator and photographer Bill McComas has led trips to the islands where Darwin first recorded the famous finches, turtles and other animals that helped him form his theory for the origins of species. Join McComas on a journey through the islands. ■

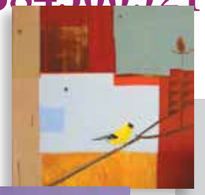
What is a Mersenne prime?

How do biosensors work? Find the answers to these questions and more on the Web site, plus submit a question of your own. ■



Elephants and baobabs:

Want to know how to escape a charging elephant or distinguish different types of animal dung? Check out one student's South African trip to study the relationship between one of Earth's largest mammals and one of the planet's most unusual trees. ■



Building an art portfolio:

Architecture professor and artist Laura Terry believes that her two professions influence one another in many ways, including in the classroom. ■

Images by; Bernard Gagnon, Baobabs tree; Fir0002, Elephant, Wikimedia Commons

Lava Lakes and Planetary Origins

Photo by Russell Cothren

A researcher and his colleagues have found differences in the iron isotope composition of basalts from a lava lake in Hawaii that point to new ways of studying the origins of the earth and other planets.

Fang-Zhen Teng, assistant professor of geosciences and a member of the Arkansas Center for Space and Planetary Sciences, and colleagues at the University of Chicago, and the U.S. Geological Survey report their findings in *Science*.

The researchers examined iron isotopes in basalt samples from the Kilauea Iki lava lake on the main island of Hawaii. Isotopes have the same chemical properties but different weights, so some processes cause what looks like the same material to behave differently – often separating the two. Such separation can tell scientists about how the material containing the isotopes formed.

Until now scientists thought that isotope fractionation occurred at low temperatures and with elements of low molecular weight. Because of the heat and iron's molecular weight, scientists thought that the process that formed basalts did not separate iron isotopes.

Teng likens the change in iron isotopic composition in basalts to the baking of a cake: With a cake, you start out with certain ingredients, but the baking process changes the ingredients and their proportions within the cake. In the same way, the process that makes basalt magma through partial melting of the mantle rocks changes the iron isotope compositions.

Photo from U.S. Geological Survey

Past studies examined basalts, but did not study the individual minerals found within a basaltic rock.

"We analyzed not only the whole rocks, but the separate minerals," Teng said. The minerals examined showed iron isotope separation.

If basalts from planets have similar iron isotope separation, it suggests that they formed through heat processes similar to those on Earth. ■

Consumers Misinterpret Trans-Fat Information

Without supplemental information on recommended daily value, many consumers don't understand the meaning of trans-fat content on the Nutrition Facts panel, according to marketing researchers.

Betsy Howlett, professor of marketing in the Sam M. Walton College of Business; Scot Burton, Wal-Mart Chair in Marketing; and John Kozup of Villanova University said that the new Nutrition Facts panel won't help consumers make healthy choices unless they have additional information about trans fat and what constitutes high levels. Their findings were published in the *Journal of Public Policy & Marketing.*

"Nutritionally motivated consumers lacking appropriate prior knowledge make inappropriate product judgments," said Howlett. "This is a troubling, unintended consequence of the current trans-fat disclosure on the Nutrition Facts panel."

Trans fat, found in many fried foods and baked goods has no nutritional value. Medical research has shown that trans fat raises levels of "bad cholesterol," which increases the risk of heart disease.

The researchers wanted to know if consumers benefit from knowing the amount of trans fat in a given food product. They examined how trans-fat information on the Nutrition Facts panel influences risk perceptions and purchase intentions among consumers at risk for heart disease.

Unlike other panel categories, trans fat does not have a percentage of recommended daily value. This creates a misunderstanding for people with no prior knowledge of trans fat and its associated potential health risks.

The researchers conducted two studies. The first asked whether supplemental information about negative health effects associated with trans fat resulted in different behavior among consumers. In this study, the researchers also wanted to know if consumer knowledge was low in the absence of information about trans fat. The second study sought to replicate aspects of the first but also examined the role of differences, such as nutrition motivation, in decision making.

"For a majority of consumers, basic information disclosure about this lesser-known nutrient has a relatively minor impact on product perceptions and evaluations, unless there is additional information available to help them better understand trans-fat levels," Burton said.

The second study considered consumers' motivation to process nutrition information. The researchers found that higher levels of motivation and knowledge worked together to result in lower purchase intentions and greater disease-risk perceptions for products high in trans fat. Motivation alone did not lead to healthful purchase intentions.

In both studies, claims such as "low in trans fat" or "zero trans fat" positively affected nutrition perceptions. In the second study, such claims favorably influenced purchase intentions for more nutritionally motivated consumers. ■

To find Campylobacter jejuni, look in the biofilms

Campylobacter jejuni, a pathogen found in chickens, is the nation's leading cause of foodborne bacterial diarrhea, so poultry producers look for ways to control it before the birds go to processing. The bacterium is susceptible to stress – so what keeps it going?

It seems the bug latches onto colonies of bacteria – biofilms – and uses them as places to thrive in ways the *Campylobacter jejuni* would be less likely to do on its own.

"The capture of *C. jejuni* could be correlated to the amount of biofilm present," said Irene Hanning, a post-doctoral associate in food science at the University of Arkansas System Division of Agriculture who investigated the issue for the Food Safety Consortium.

Many bacteria can form a biofilm, an assemblage of bacteria encased in a sticky substance. A biofilm provides protection from threats to bacteria's existence. *C. jejuni* has had a major disadvantage in that it doesn't do well at making its own biofilm. So instead, it moves into other biofilms.

The hosts can be any of several bacteria, but *C. jejuni's* most prevalent host turns out to be *Pseudomonas,* which also serves as the main spoilage bacteria on chicken carcasses, Hanning said.

Hanning looked at the ability of *C. jejuni* to survive from biofilm populations isolated from four places: a drinking unit in a chicken house, a drain under a plucker in a processing plant, a retail chicken carcass and a crate used to haul live chickens. No *C. jejuni* was found on the growth surfaces outside of biofilms that had already been established.

Photo by De Wood; digital colorization by Chris Pooley, USDA

"These experiments indicated that *C. jejuni* can be captured and harbored by a biofilm regardless of the bacterial constituents," Hanning said. "Therefore most biofilms should be considered as having the potential to promote and harbor *C. jejuni.*" ■

Modeling Health Care Logistics in a Virtual World

Inefficient health care delivery contributes to rising costs and compromised quality of care and patient safety. To address this problem, researchers are using Second Life, the popular three-dimensional virtual world in which people work and play online, as a platform for modeling efficient health care delivery.

"As most people know – usually by personal experience – modern U.S. health care is hugely expensive and does not always assure safety," said Craig Thompson, professor of computer science and computer engineering. "What we're doing is exploring virtual worlds as a model for efficient operations."

Thus far, researchers under the direction of Thompson and Fran Hagstrom from the College of Education and Health Professions have created a virtual hospital with operating suites, patient rooms, laboratories, a pharmacy, waiting rooms, stock rooms and bathrooms. The building also includes furnishings and diagnostic and medical equipment. Avatars – virtual representations of doctors, nurses, staff and patients – populate the site.

The researchers created trucks and other "smart" equipment to simulate the hospital supply workplace. The equipment is smart because it sports virtual RFID tags, which are similar to barcodes but can identify individual items. The system tracks the location of things and who is responsible for them.

But how will people, virtual or real, and objects work together to make a more efficient system? Consider this scenario: An avatar enters a warehouse to fill a supply order. Once inside, the avatar loads containers of supplies or equipment onto pallets, which are then loaded into a truck. The avatar drives the truck to the hospital loading dock and unloads the pallet. A re-supply robot takes the pallet to supply rooms and uses RFID to access a database that knows the items on the pallet and where to deliver the supplies. Because every item is wired to a computer network, a management system can monitor inventory and distribution in real time without human manipulation.

Illustration submitted by Craig Thompson

"In the 'everything is alive' vision, objects talk to each other," Thompson said. "Our virtual objects do this, and, increasingly, so can wirelessly connected real-world objects."

Please visit http://vw.ddns.uark.edu for more information or visit the "University of Arkansas" island in Second Life. ■

3-D Atlas Reveals Undiscovered Sites

Researchers are developing an archeological atlas of the Middle East that can be used with contemporary mapping applications to pinpoint locations. This will make decades-old satellite imagery available to scientists who need to know what a landscape looked like before the spread of cities and agriculture.

Archeologist Jesse Casana and geoscientist Jackson Cothren published an account of the methods and examples of their work in the journal *Antiquity.*

Using declassified images from a government satellite program called CORONA, the researchers are working with high-resolution digital scans distributed by the U.S. Geological Survey of film shot between 1967 and 1972.

Looking at the ground from above can help scientists find archeological sites and identify ancient roads, fields and canals, but over the past 40 years in the Middle East in particular, expanding cities and agriculture have destroyed or obscured much of the archeological record. Casana estimates that there are hundreds, perhaps thousands, of unrecorded sites under reservoirs or beneath cities.

Image from CORONA

"This old imagery is an irreplaceable resource for archeologists because it preserves a picture of things that were visible 40 years ago," Casana said. "You can look at this beautiful new imagery, but if a site is at the bottom of a reservoir, you're really not going to see it." ■

Legal Case Will Influence How Lawmakers Address Water Pollution

Over the past 30 years, Oklahoma and Arkansas have engaged in three legal cases over the quality of water that flows from northwest Arkansas into northeast Oklahoma. A legal scholar says the most recent conflict highlights an issue of national significance and will likely influence methods in which legislators and policymakers address water pollution.

"The legal cases between Oklahoma and Arkansas evolved from a conflict over point-source pollution involving municipal wastewater discharge to a conflict over nonpoint-source pollution in the form of nutrient runoff from poultry litter," said Harrison Pittman, assistant research professor and director of the National Agricultural Law Center.

The Clean Water Act has led to improvements in water quality since Congress passed the legislation in 1972. Since that time, the focus has been to address water pollution from so-called "point sources," which the law defines as "discernable, confined and discrete conveyances, including … any pipe, ditch, channel, tunnel, conduit, well … from which pollutants may be discharged."

However, nonpoint-source pollution in the form of storm-water runoff from parking lots, fertilizers from lawns and golf courses, and nutrients from farms has emerged as the new challenge in addressing water quality.

Animal agricultural production, considered to be a source of nonpoint-source pollution, has changed during the past several decades. Since 1972, the number of hog, cattle, poultry and dairy farms has decreased dramatically, but the size of each farm has grown.

"A consequence of these structural changes is that extraordinary amounts of animal waste are produced in geographically limited areas," Pittman said. "This waste must be disposed of or utilized somehow, and a traditional and common method is for producers to apply it to the land as fertilizer."

The Clean Water Act addresses point-source and nonpoint-source pollution differently. Because nonpoint-source programs through the Clean Water Act are regarded as voluntary, that law is not the best means for addressing it.

"With respect to agriculture specifically," Pittman said, "policymakers may begin to consider new policy approaches to addressing nonpoint-source pollution. Perhaps there's a better way to address these problems without litigation or overly burdensome government regulation."

Pittman suggests expansion of the Conservation Security Program, a voluntary, science and technology-driven federal program that provides financial and technical support to farmers and producers who initiate specific conservation practices in their agricultural operations. In addition to its environmental and financial benefits, the program could be viewed as a transition from traditional federal subsidization programs to the adoption of market-oriented policies that would comply with U.S. commitments to the World Trade Organization.

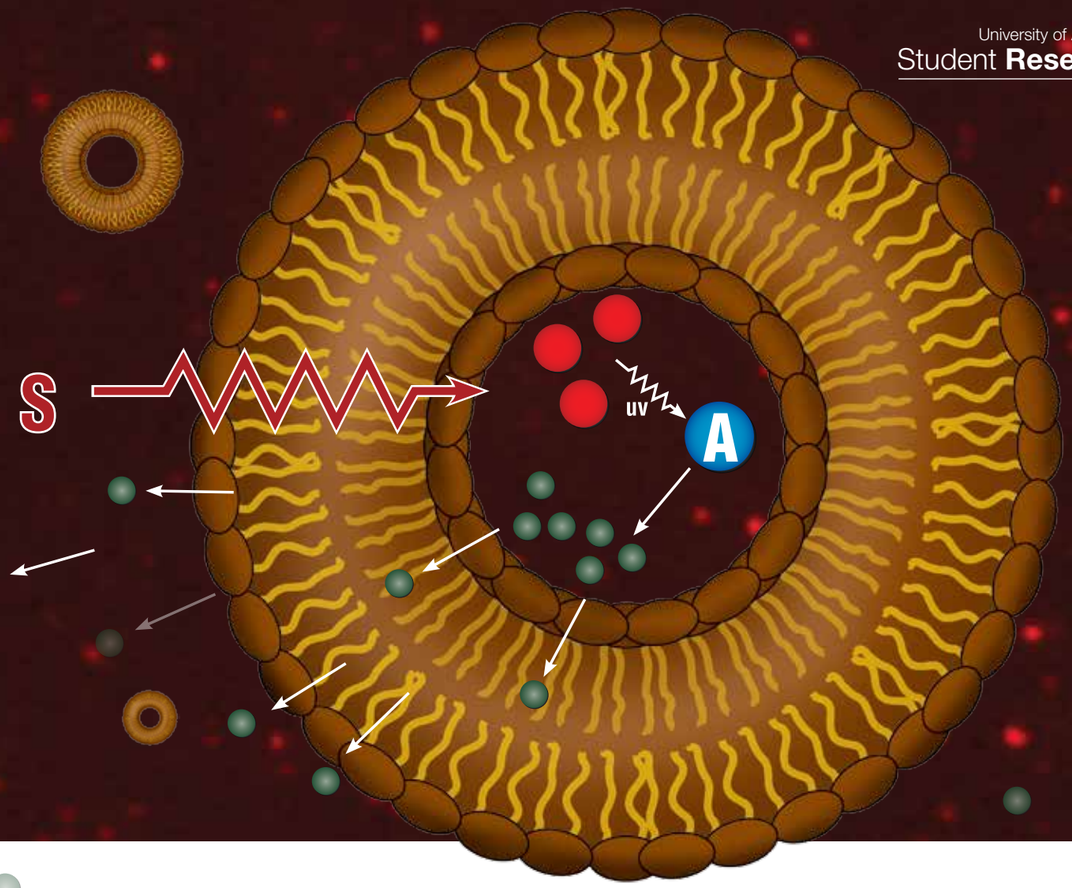
The paper was published in the *Journal of Food Law and Policy.* ■

University of Arkansas
Student **Research**

Researchers Use Fat to Fight Cancer

By Jessica Powviriya

Photo by Russell Cothren



Despite medical advances, humans are not winning the war on cancer. Cancer will overtake heart disease as the world's top killer by 2010, according to the World Health Organization. Cancer diagnoses will reach 12 million and deaths related to cancer are expected to reach 7 million this year.

Treatments for cancer include chemotherapy, radiation therapy and surgery. Unfortunately, current cancer treatments can devastate the body as well as cancer cells.

"The problem with current cancer treatment is that the chemicals attack more good cells than the bad," Gregory Salamo, the Joe N. Basore Professor in Nanotechnology and Innovation, said. "We try to push the body to the limit to possibly kill the cancer."

These therapies sometimes succeed, but in the process, they may kill the patient, he said.

Conclusion? Cancer is bad. Cancer treatment that potentially kills is bad as well. What else is bad… fat? Not according to Rachel Lee, a physics and chemical engineering senior in the honors college who is researching how liposomes made from fat act as carriers for controlled drug delivery.

Lee has been on a research team that is looking at ways to use new technologies – with the help of artificial cells made from fat – to deliver cancer-fighting drugs directly to cancer cells.

The research team is funded by a $1.6 million Howard Hughes Medical Institute grant through 2010. The grant brings together undergraduates in different disciplines in a studio environment to solve interdisciplinary problems.

Lee is one of six undergraduates who work on this project. All are seeking a better drug delivery system, but they are using different approaches.

Their research is an essential part of a bigger cancer research plan. The team of faculty include Salamo and Daniel Fologea in physics, Xiaogang Peng and David Paul in chemistry, and Ralph Henry, David McNabb and Ines Pinto in biological sciences. They work in conjunction with the University of Arkansas for Medical Sciences located in Little Rock.

Scientists at the medical school are researching how to target cancerous tumors with drugs released from liposomes.

Two chemistry students are creating quantum dots, or nanoparticles of a crystal that easily emits light, to test for different properties of the healthy and cancerous cells.

Two biology students are growing different cell lines and seeing how the quantum dots and other parts of the group's drug delivery system impact the cells.

Lee is working with liposomes with another physics student. A liposome is an artificial microscopic sac consisting of an aqueous core enclosed in one or more lipid layers. Liposomes have cores that are able to hold and protect concentrated drugs from degradation inside the body with its bilayers.

Liposomes are currently FDA approved for use with the popular cancer treatment drug, doxorubicin. One such doxorubicin formulation is Doxil. Lee works to see how the liposomes, loaded with doxorubicin, would react with external stimuli and whether they would completely release the medication it carries. Lee thinks the research can further the use of doxorubicin, but the liposomes could also be modified to incorporate other drugs.

For this project, Lee had to manufacture liposomes from fats, a time-consuming process that must be finished before any research can be started. The lipids needed from the fats are dissolved in chloroform, which allows them to be mixed in the desired proportions. After mixing, the solution is dried under vacuum to produce a lipid cake.

The next few steps in Lee's research process sound like a sci-fi movie from the not too distant past. She works with extruders, spectrofluorometers, fluorescent microscopes and electrodialysis machines. She also uses nanotechnology to make and study the liposomes.

An extruder is used to push the liposomes through a membrane that produces the different sizes of liposomes needed for Lee's experiment.

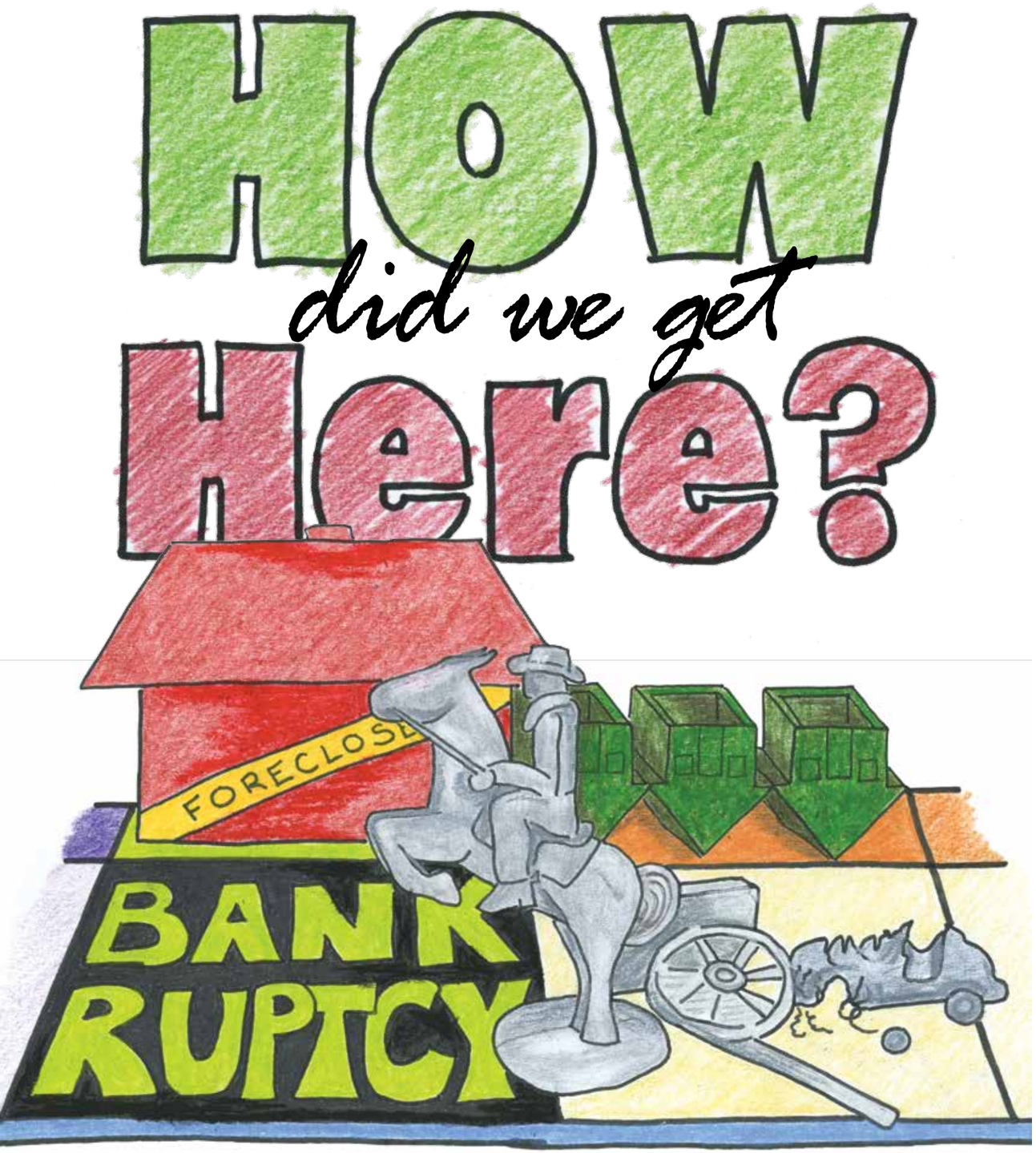
Using liposomes as a controlled delivery method for medications can provide a much higher dose of medication to the needed areas without inducing the severe side effects that normally limit dosage, especially in the treatment of cancer. Lee's goal is to find the best possible liposome for cancer treatment.

"It's nice to think that my work could eventually lead to better cancer drugs," Lee said.

The simple lipid bilayers make it easy for scientists to concentrate the drug, evade early removal from the body and release the drug when required. After the liposome releases the drug, the lipids are removed from the body by its normal cleaning systems.

The results of Lee's study support the further use of liposomes as drug carriers because of their uniformity, stability, and ability to evade the immune system's self-defense while still concentrating a drug inside the cell.

The university is pursuing patent protection and is seeking a commercialization partner for some aspects of this research. ■



Economists and financial researchers guide the average reader through the history of the current economic crisis.

By Matt McGowan
Illustrations by Amanda Ryan

The news came in a seemingly bottomless and never-ending ticker, like some kind of wicked messenger smacking us upside the head with the proverbial two-by-four. Through September, October and most of November, we watched stunned and amazed as Wall Street's venerable financial institutions bled and government officials scurried around, frantically searching for a tourniquet.

But the news of the unfolding financial crisis and the certainty of an imminent credit crisis did not surprise everyone. Many months before the mid-September firestorm of bankruptcies, bank failures, buyouts and bailouts, the effect of which deepened an already disturbing mortgage market crisis and further propelled the United States into severe financial trouble, researchers in the Sam M. Walton College of Business monitored the developments that contributed to current financial woes.

Although they view the crises from slightly different perspectives, they agree that the U.S. economy won't recover anytime soon. It could take months, perhaps years to climb out of the recession. The researchers also agree that there are many unknowns, because the U.S. economy historically has not experienced aspects of the current crisis, so there really isn't a blueprint for how to fix it.

"One thing we know for sure is that changes will be made so that this particular kind of crisis doesn't happen again," says Tim Yeager, associate professor of finance in the Walton College. "But we'll have to struggle for a while. It'll work out over time. That's just the nature of the capitalist system. Every so often, we go on these credit binges. It's been happening for hundreds of years, and we haven't yet figured out a way to change it."

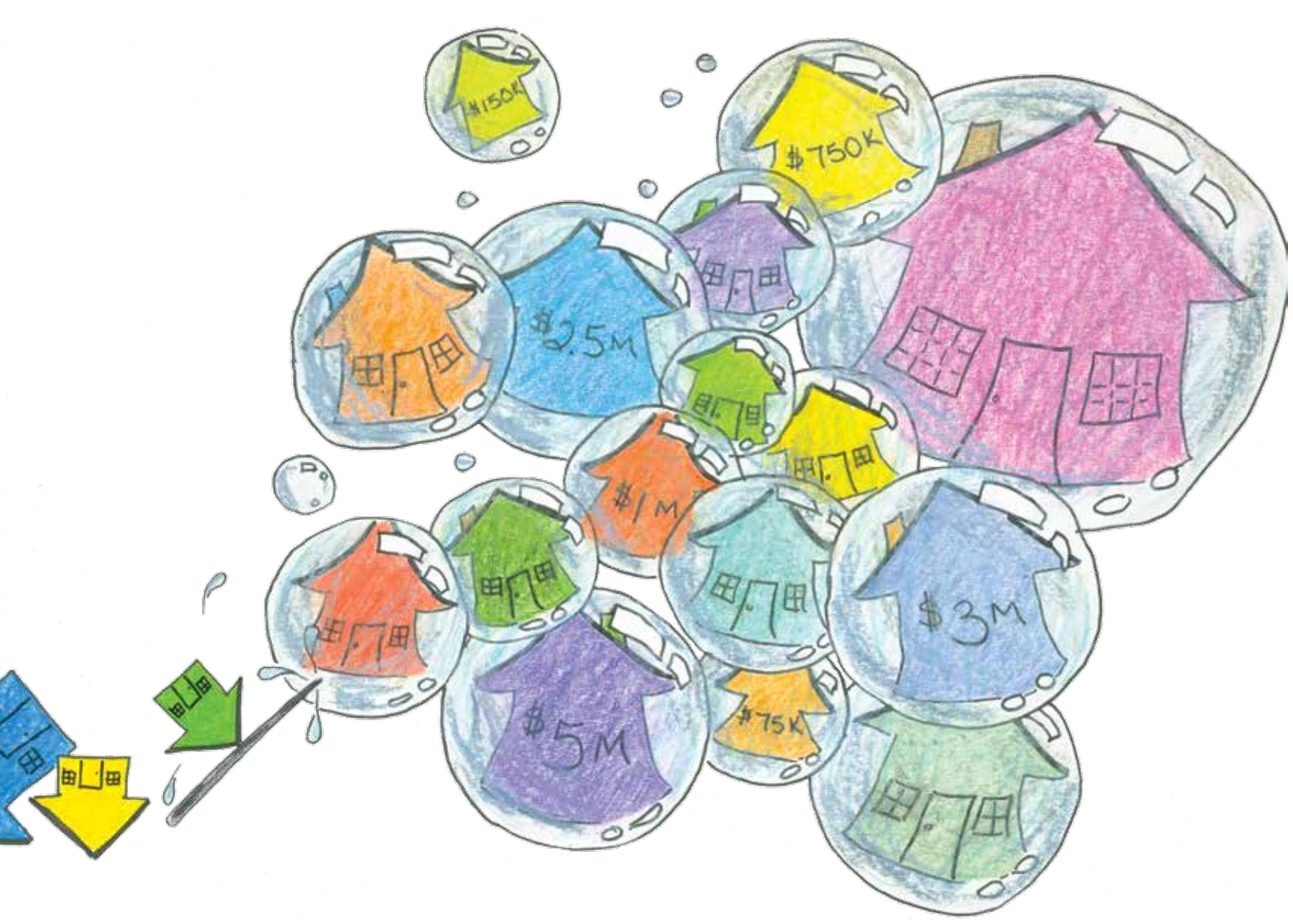
How did we get in this mess?

Today's problems did not materialize over night, despite the sudden and dramatic events of mid-September and the subsequent runaway train of bank failures and ultra-volatile stock market. Yeager and his colleagues say the roots of the financial crisis go back at least five, maybe eight years. The causes are complex but can be explained.

It may help to describe the crisis as not one, but three distinct, yet interrelated crises in housing, finance and credit. Market forces and trends within each crisis helped create or aggravate other crises, the researchers say. Also, in the era of economic globalization – a time in which countries and people, especially investors, have never been more interconnected – the problem cannot be fully understood without looking beyond U.S. borders.

For example, several years before Americans ever heard terms such as mortgage-backed securities and credit-default swaps, demand for the U.S. dollar, primarily by Asian economies but also foreign investors in general, rose sharply, says Javier Reyes, assistant professor of economics. Reyes studies international trade networks and financial "contagion," which is the transmission and impact of financial crises.

In the 1990s, Reyes says, these foreign countries built large monetary reserves to avoid the negative effects of sudden stops in capital and to protect themselves against contagion. The countries were eager to invest large sums in American companies, U.S. treasuries and commercial paper, which they did. The effect of this investment generated unprecedented liquidity in U.S. banks.



The housing bubble

The massive influx of capital from abroad pushed interest rates down and motivated banks to promote credit, says Kathy Deck, director of the Center for Business & Economic Research. One of Deck's primary tasks is monitoring housing, construction and real estate in general. She focuses on Arkansas but also pays close attention to national trends.

The housing bubble, Deck says, played a major role in the current economic crisis. In short, Americans built and bought too much house. The combination of immense bank liquidity, low interest rates and credit promotion, including innovative financing mechanisms (which will be addressed later) created a real-estate bonanza like none other, except perhaps the housing boom immediately following World War II. From the late 1990s to about 2006, commercial and residential construction exploded. Appreciation rates soared.

"Developers looked out there and said 'I can make a ton of money right now because money's cheap, and everybody wants a nice house, and I'm going to build it,'" Deck says. "So you had this overinvestment, and at the same time an explosion in the ability of people to get financing. This combination caused us to get exuberant, and we put ourselves in a situation where we had to have ever-rising housing prices for the economy to work. That was the bubble. And, of course, it burst. We just couldn't sustain that kind of growth."

As little as a decade ago, if you wanted a home loan, you went to a local bank, and a loan officer offered two choices, a 15- or 30-year, fixed-rate loan. What happened, Deck says, is that the real-estate mortgage industry changed and began offering a variety of products – no money down, adjustable-rate mortgages, interest-only mortgages and others – to choose from. Only later did government officials, investors and consumers discover that many of these products were not sound.

The financial crisis

How and why did this happen? Yeager says these questions can be answered by looking at the evolution of the financial system behind mortgage lending. Banks were flush, and many could not resist the urge to use their liquidity to earn even greater sums of cash. The high profits earned by early subprime lenders – financial institutions that provided credit to high-risk borrowers – and fueled by lax federal regulation drove even more lenders into the market.

Banks began bundling these high-risk, subprime loans into pools, otherwise known as mortgage-backed securities, and backed the securities with something called credit-default swaps, a sort of cooked-up, industry-manufactured euphemism for insurance, which were not subject to insurance regulation. Banks then sold these loans to foreign countries and investors who were hungry for alternative investment opportunities in a low-interest-rate environment.

So greed played a role, but that's only part of the explanation, a fact that disappoints angry citizens who can't understand how the federal government could step in today and save these financial institutions from ruin. Borrowers, federal agencies and even Congress must accept culpability as well, says John Dominick, also a professor of finance. Dominick says consumers did not invest enough energy or time to learn about mortgage-loan characteristics. So they bought more than they could afford, made possible by these bad loans that, in many cases, more than doubled monthly payments when the housing bubble burst and interest rates went up.

Also, under pressure from the mortgage industry, Fannie Mae and Freddie Mac, the federal mortgage agencies, relaxed underwriting standards, which allowed firms to package even more bad mortgages. And members of Congress, motivated by a social imperative to make home ownership available to all Americans, pressured Fannie Mae and Freddie Mac to provide expanded approval to many risky consumers.

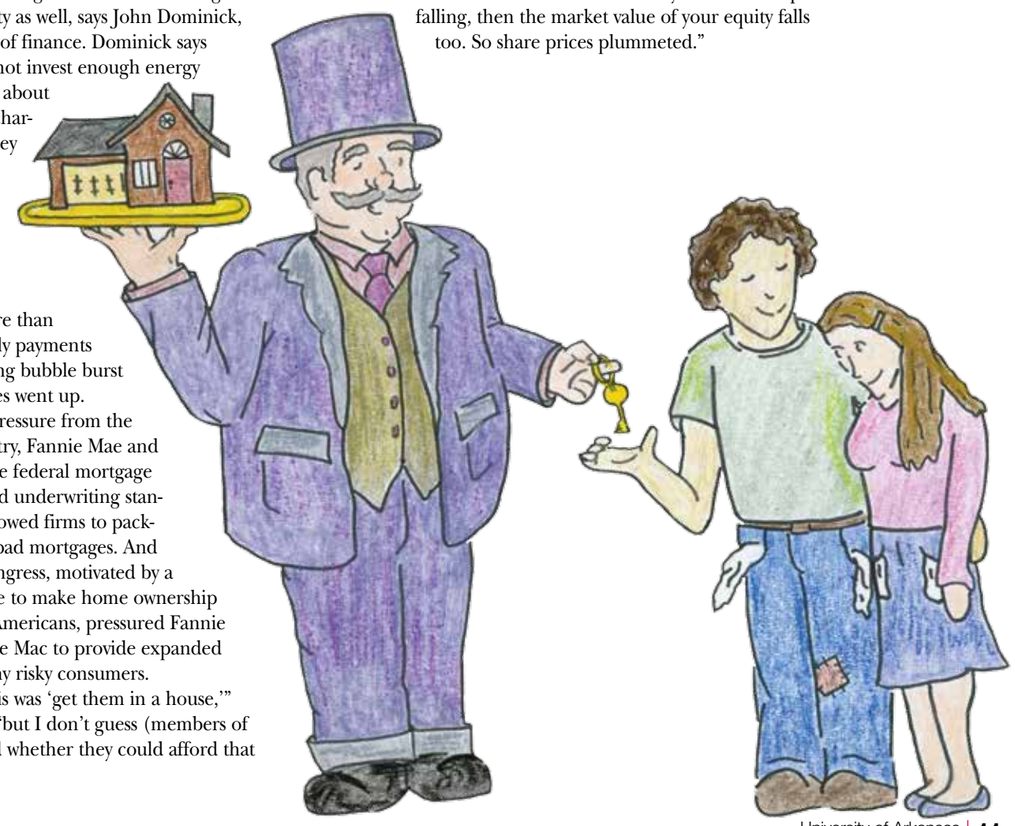
"The emphasis was 'get them in a house,'" Dominick says, "but I don't guess (members of Congress) cared whether they could afford that house or not."

Combined, these factors – foreign investment, bank liquidity, creative financing and packaging of subprime loans, poor investment-banking regulation and lax underwriting – created the financial crisis.

"So all of these things mixed in led to an impossible situation," Yeager says. "And then you just add gasoline in terms of low interest rates and high housing prices, and the whole thing is bound to burst into flames."

The inferno included a barrage of defaults, which at first weren't harmful to banks because they could still sell houses at a profit. But then demand for housing went down – because plumbers and teachers could not afford a $1.2 million house in Sacramento – so property started to depreciate significantly. Then Wall Street banks and Fannie and Freddie woke up and found themselves sitting on a mountain of worthless assets.

"All of a sudden, it became clear that these subprime mortgages were trash," Yeager says. "Losses were high and nobody wanted to buy anymore. So the loans sat on the banks' books like perishable fruit, degrading in value until they were rotten. Banks had to write off billions of dollars in loans, which took a direct hit on their capital, because when the market value of your assets keeps falling, then the market value of your equity falls too. So share prices plummeted."



We need a bailout!

It started in the spring of 2008 with the collapse of Bear Stearns. The government stepped in to arrange a buyout by JP Morgan, with the Fed picking up a large share of potential losses. The crisis spread over the summer with Fannie Mae and Freddie Mac. Officials at both organizations, which then were still shareholder-owned corporations rather than part of the Treasury, saw the storm coming and cried for help.

"They had a couple hundred billion in debt coming due," Dominick says. "They had defaults on these loans, and like all good children do, they ran home to mommy and daddy and said 'we need a bailout,' and, of course, they got it."

Then came Lehman Brothers and American International Group, or AIG. In mid-September, about a week after the Treasury took over Fannie and Freddie, discussions among government and finance officials to prevent bankruptcy at Lehman broke down, and the company failed. On Sept. 16, the Federal Reserve bailed out AIG with an $85 million infusion of cash. But the deal did not keep the company's stocks from falling.

After much debate and one rejected plan, the big bailout came on Oct. 1, when Congress approved the Troubled Asset Relief Program, or TARP, which freed up $700 billion in government funds. Initially, officials at the Federal Reserve and Treasury talked about using the money to purchase troubled assets, a plan that Yeager argued would have been a disaster and waste of taxpayer money. Instead, Federal Reserve Chairman Ben Bernanke and Treasury Secretary Henry Paulson settled on a "capital injection" program in which the federal government has poured billions of dollars into banks in exchange for equity shares or partial ownership stakes.

A crisis of credit

Despite government intervention, the combined impact of the housing and financial crises created a more disturbing crisis, one that has corrosive, pervasive and potentially long-term effects on the real economy, says Raja Kali, associate professor of economics.

"What we have now," Kali says, "is a crisis of credit, which is causing the economy to seize up. People are worried about what they don't know, and this is not good for an economy that depends on credit and the trust that inherently accompanies it. Right now, no one is willing to loan money, and this is a real problem because the functioning of the economy critically depends on the flow of credit."

This dynamic is much broader and deeper than the simple act of consumers using credit cards to purchase Christmas gifts. Lack of credit affects virtually every business transaction, and repercussions reverberate and trickle down to all kinds of relationships, not only between consumers and merchants but also business to business and business to employee.

For example, business investment and inventory depend on short-term credit because of lags between expenditures and receipts. In this situation, when credit is cut off, businesses cut back not only on investment and inventory but also employment. They can't make payroll, so they lay off workers.

Paulson, Bernanke and every economist worth the price of their education all know this, and it is exactly why the Federal Reserve and Treasury have deposited massive funds into these banks – to thaw the credit market, to get money flowing, to prevent the economy from seizing up. So far – before the end of the 2008 – it hasn't worked. In an effort to stabilize their balance sheets, banks are holding on to the money and waiting for the fear to subside and a modicum of trust to return.

This will take time, says Kali, because relationships have been damaged, and trust, the essential ingredient of the credit market, won't return overnight.

Where do we go from here?

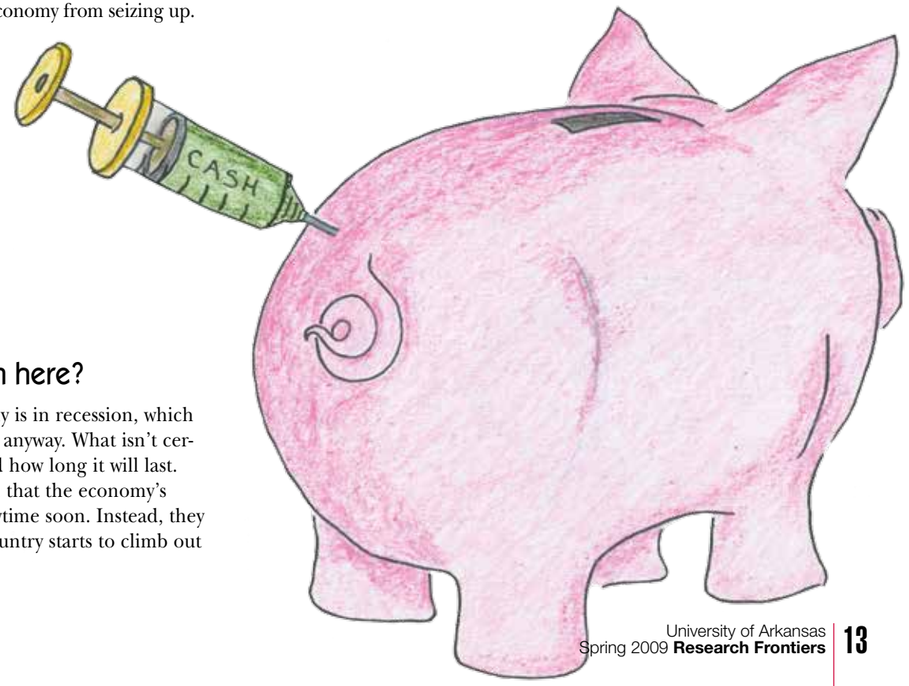
For certain, the U.S. economy is in recession, which Kali and others say was coming anyway. What isn't certain is how deep it will dive and how long it will last. But all of the researchers agree that the economy's problems will not be solved anytime soon. Instead, they will likely worsen before the country starts to climb out of the recession.

To be sure, Americans will suffer. Unemployment, a critical economic indicator, will continue to rise. Yeager guesses that it might peak somewhere between 7.5 and 8 percent this spring – high when compared to 5 percent rates over the past 15 or more years, but a far cry from unemployment seen during the Great Depression.

Manufacturing, which suffered before the crisis, will cut back even more. Retail workers will get laid off because people are spending less on luxury items. The recession has and will continue to significantly affect construction, insurance and real estate jobs. Yeager says that the safest areas, those least affected, are government, education and health care.

Officials at the Federal Reserve and Treasury have taken necessary steps to prevent the crisis from worsening, says Kali. But only time will tell if the intervention will work as is hoped.

"A similar financial crisis hit Scandinavian countries in the early 1990s," he says. "In that case, Sweden and Finland took up equity stakes in banks and gave quick injections of cash, just as the Fed and Treasury are doing now. And it worked; the financial system recovered, cash and credit flowed, the banks recovered and eventually the governments were able to sell their equity stakes at a profit. And none of this passed much burden to the taxpayer. That's kind of the ideal scenario, a justification for intervention. Maybe we don't like it, but probably the best thing to do is hold our noses and just do it." ■



Darwin
Visits the Islands and Discovers a New World

By Barbara Jaquish

Island Photos by William F. McComas

"When on board H.M.S. Beagle, as naturalist, I was much struck with certain facts in the distribution of the inhabitants of South America...."

Thus begins Charles Darwin's *The Origin of Species By Means of Natural Selection*, a book that has changed the way humans understand the world and our place in it.

Around the globe, 2009 is being celebrated as the Year of Darwin in recognition of his birth on February 12, 1809, and the publication of his landmark book, *Origin of Species*, on November 24, 1859.

In more than 25 years of teaching science in high schools and science education in universities, William F. McComas, the Parks Family Professor of Science Education at the University of Arkansas, has introduced hundreds of students to Darwin and evolution. He has prepared university students to become science educators, confident and able to teach a subject that has had a history of controversy. The author of three books about teaching science, he has traveled extensively worldwide – including to the Galapagos Islands – pursuing an interest in photographing ecologically significant places.

In his science textbooks and in the classroom, McComas uses teaching about evolution as an opportunity to address misconceptions about science. In particular, one of the most misunderstood notions surrounding evolution is the distinction between the reality of evolution as a series of ongoing events in the history of life and the explanation for how evolution has occurred, the theory of natural selection.

"Does life seem to have changed through time since its origins? The answer is yes, yes and yes," McComas said. "There is no question that the record in the fossils is one of change through time. And that's what evolution is. Period. Evolution has occurred – it is a fact. The big question for Darwin was how change through time could take place."

Darwin's answer, the theory of natural selection, has been subject to extensive questioning and testing.

"If there's any argument about evolution, it deals with fine-tuning the elements of the mechanism. Even after 150 years of testing and criticizing natural selection, the theory holds up beautifully," McComas said.

One of the reasons to celebrate Darwin's genius, McComas explained, is that he developed an accurate theory of the mechanism of evolution without knowing much about how traits are inherited. The first true test came with Gregor Mendel's discovery of the mechanism for inheritance, which we now call genetics. Natural selection as the explanation for evolution "passed this test brilliantly."

Darwin had "put the puzzle together without all the pieces and with no picture on the cover of the box," McComas said.

Beach Background Photo by Eric Pipkin

Darwin and the Islands

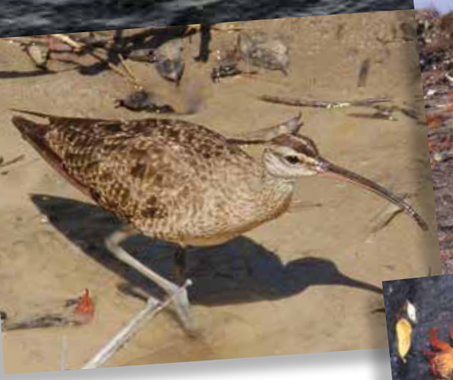
While Darwin's discoveries are popularly linked with the Galapagos Islands and its flora and fauna, McComas noted that Darwin did not suggest the mechanism of natural selection while in the Galapagos Islands or even on his trip.

"The most important thing to understand about the Galapagos Islands is that by the time Charles Darwin got to those islands he'd already spent a good bit of time on other islands," McComas said.

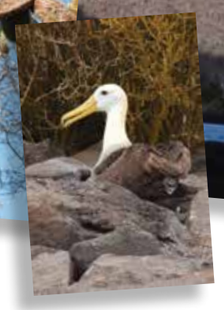
For Darwin, the Galapagos were another example of populations reproducing in isolation and an opportunity to see whether the pattern he'd observed on other islands was repeated. On the Galapagos Islands, he again found something strange and thought provoking. While the creatures on the islands come from the tropics, the Galapagos are an entirely different environment – remote volcanic islands surrounded by salt ocean. This raised a question for Darwin about why a creator would take something from the lush tropics of South America and make extensive and sometimes dramatic changes to it so that it could live successfully on such arid islands. That question, McComas said, "was the spark that finally led Darwin to accept that evolution had occurred."

As Darwin wrote in his introduction to *Origin of Species*, "These facts seem to throw some light on the origin of species – that mystery of mysteries…. On my return home, it occurred to me in 1837, that something might perhaps be made out of this question by patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on it."

Darwin's realization that evolution had occurred "gave him something to think about for the rest of his life," McComas said. With the reality of evolution established, Darwin could turn his attention to revealing its mechanism. The inhabitants of the Galapagos Islands had provided him important evidence.



Island Photos by William F. McComas



Birds

Although Darwin's finches have become a hallmark of his discoveries, "Darwin was much more taken with the mockingbirds than the finches," McComas said. Before he arrived at the Galapagos, he had formed the idea that the same species would be present on all the islands. The mockingbirds challenged that notion. He was surprised to find that there were four distinct species of mockingbirds in the Galapagos Islands.

His assumption about the distribution of species led to "one of the most interesting mistakes in the history of science." As McComas tells the story, while Darwin went from island to island collecting finches, he did not document the name of the island from which each bird came. The good news is that two other people from the ship were helping him collect specimens. Because they didn't have any prior notion about what they might find, every time they shot a finch, they wrote down the location. Later, after Darwin had left the Galapagos and realized his mistake, he was able to reconstruct a lot of the data from the specimens that were properly labeled by his two assistants.

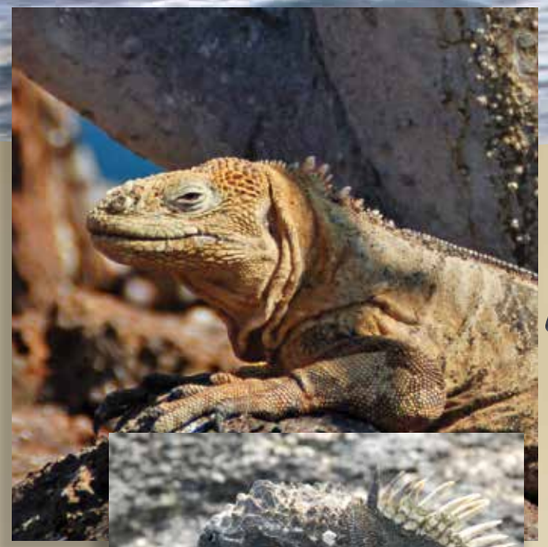
When Darwin returned to England, he gave his entire finch collection to John Gould, a famous British ornithologist. While studying and cataloging the collection, Gould realized that all the finches were actually from a common stock and that some of the unidentified birds Darwin had collected were actually finches.

Mockingbirds

Photos by William F. McComas

Finches

Iguanas



It's clear that many of the animals living on the Galapagos Islands did not originate there but carried the traits necessary to survive and for their progeny ultimately to evolve into new forms. For example, a tree-living iguana from the tropical coast of South America somehow got washed out to the islands. Even if those iguanas had been conscious of their plight, McComas said, "There wasn't anything they could do about it beyond the traits that they brought with them. The only tool that any plant or any animal ever brings with it is in its genetic composition. It cannot produce new traits just because it might be useful to do so."

On the Galapagos Islands, evolution took the iguanas in two different directions, McComas explained. Today hardy land iguanas with pointed faces get in amongst the cactus needles to feed. The others are the world's only species of marine iguanas that live on the shore and feed in salt water. With their blunt faces they are able to nip close to underwater rocks and shave off the algae, their primary source of food. While the two iguanas look entirely different today, their genes show they came from a common ancestor, the South American tree iguana.

Tortoises

"When Darwin arrived in the Galapagos Islands, the British governor there pointed out that some of the tortoises tasted better than others," McComas said. "Darwin wondered why there would be such differences between the tortoises." Again, Darwin assumed that with islands so close together, he would find the same creatures on them. Yet, McComas said, "With just a bit of help, even a third grader could look at the pictures of the tortoises and say that one came from a dry island, and that one came from a wet island."

The shells of the dry island tortoises have pronounced flared plates, known as phalanges. Their shells flare up at the feet and are phalanged up dramatically where the neck sticks out. This is an adaptation: tortoises that were able to stretch to get their heads farther up into the trees on the dry islands were able to feed more effectively.

On the other hand, tortoises on the wet islands "look like common box turtles on steroids." On the wet islands, McComas said, there was no evolutionary pressure to evolve the flared shells, so those individuals with even a hint of the trait did not have any advantage over those lacking phalanges.

Back in England

Even before Darwin returned to England, he shipped his collections to various experts, such as Gould, the ornithologist. Certainly, he did his senior colleagues a favor by sending them source material, McComas noted, while at the same time, he built his own reputation. When Darwin left for the voyage as a young man, no one knew who he was. By the time he returned home, he was one of the most famous naturalists in England.

Darwin spent 20 years after his return examining evidence and preparing detailed arguments to support the theory of evolution by natural selection. While Darwin was preparing the manuscript for *Origin of Species*, Alfred Russell Wallace, a naturalist-collector working in the Malay Archipelago, wrote him offering a parallel and nearly identical theory. Subsequently, papers from Darwin and Wallace were presented together at a meeting of the Linnaean Society in London in 1858. Their insights opened a new door for science.

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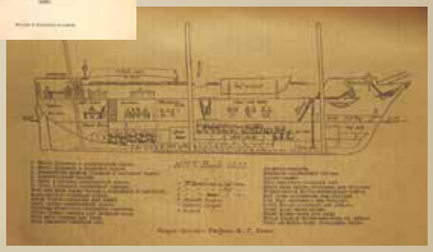
THE ORIGIN OF SPECIES



In the concluding paragraphs of *Origin of Species*, Darwin pulls back from the detailed arguments of his book to consider the wonder of evolution:

"It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us."

And he concludes, using the word "evolved" for the first time in the book: "There is a grandeur in this view of life" in which "endless forms most beautiful and most wonderful have been, and are being, evolved."

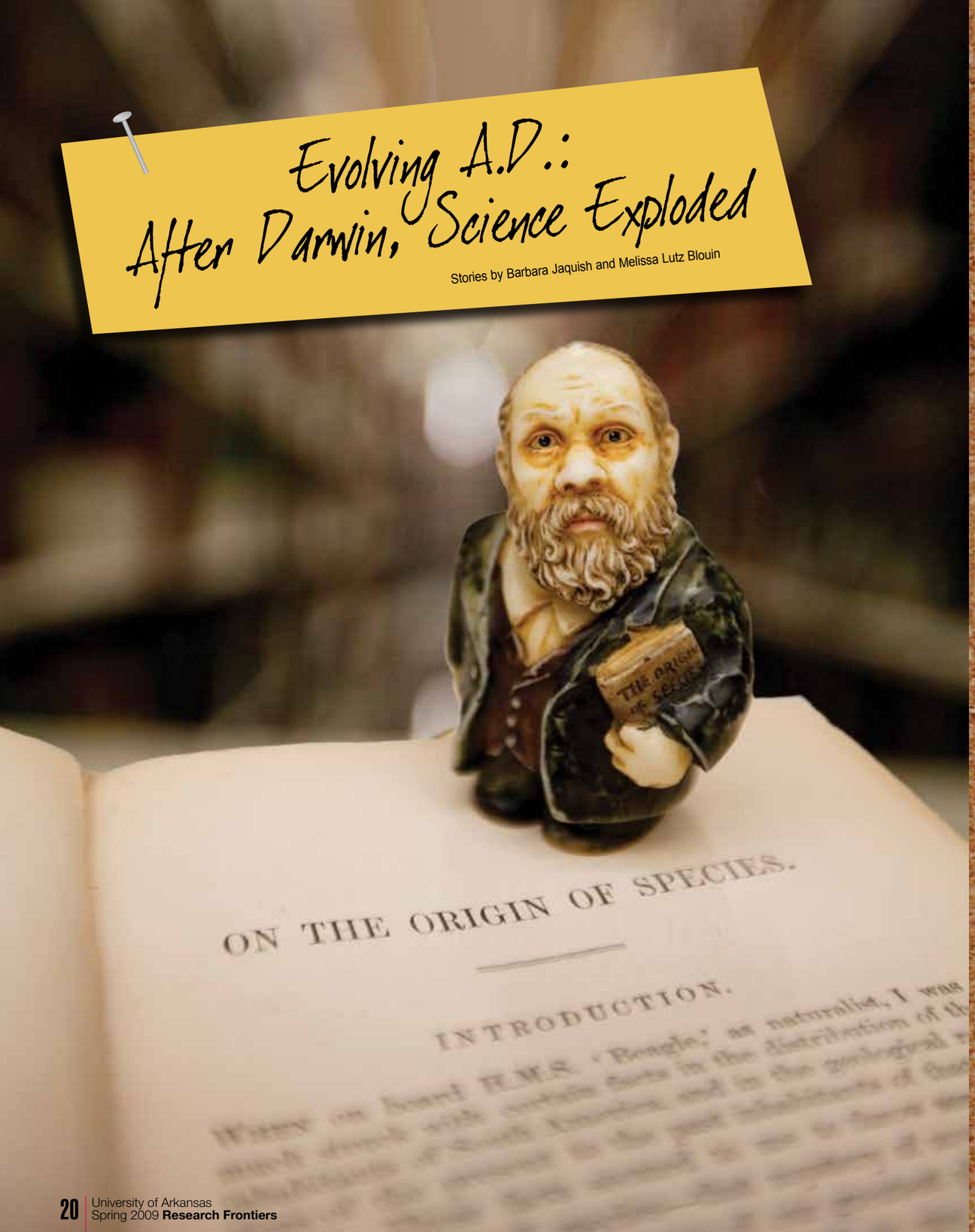
William F. McComas

William F. McComas is the Parks Family Professor of Science and Technology Education in the College of Education and Health Professions at the University of Arkansas. As a result of his professional interest in photography, he has developed photo-based instructional and resource units, a museum exhibition titled "The Galápagos Islands: Evolution's Showcase" and assignments to ecology research sites in Central America, New England and Colorado. ■

All Galapagos photos for this story were contributed by William F. McComas.

Evolving A.D.: After Darwin, Science Exploded

Stories by Barbara Jaquish and Melissa Lutz Blouin



In the 150 years since Charles Darwin's landmark book, the knowledge that species evolved through natural selection has opened the door to tremendous advances in science. University of Arkansas professors discuss evolution in a variety of fields.

MICHAEL PLAVCAN

professor of anthropology,
J. William Fulbright College of Arts and Sciences.

Darwin profoundly changed our view of ourselves," said anthropologist Michael Plavcan. "Evolutionary biology makes us part of the world rather than the center of the world." At the same time, the study of humans raises particular questions, such as "how culture should be factored into understanding the evolution of human intelligence.

"As humans became more dominant, we became more effective at exploiting the environment," Plavcan said. When we don't have to worry about predators, and when we are able to insure that food will be available throughout the year, "what becomes important is the ability to navigate social systems."

"For animals, the ability to run fast and not get eaten is primary over the ability to make friends," Plavcan explained. "But humans have occupied a niche that has reduced other pressures, allowing sociality to become dominant. To survive, I must be able to know that you will think as I do and react the way I expect. Humans have become good at thinking about what other humans think and assigning cause and effect."

Plavcan's research centers on primate and human evolution. He uses comparative analyses of living species to understand the morphology and adaptations of extinct species. Applied to the fossil record, his work has been used as a basis for inferring the evolution of social behavior in primates and early humans. In 2009, his colleagues recognized the significance of his work by naming him a Fellow of the American Association for the Advancement of Science.

"Evolutionary biology makes us part of the world rather than the center of the world."
Michael Plavcan, professor of anthropology,
J. William Fulbright College of Arts and Sciences.

DAVID A. SCHROEDER

professor of psychology,
J. William Fulbright College of Arts and Sciences.

David A. Schroeder studies pro-social behavior, a field that increasingly includes examining the genetic basis for human behavior.

"One way to insure our genes survive is to insure survival of our offspring," Schroeder said. "Thus, doing good things for close family relations has beneficial consequences."

The phrase "blood is thicker than water" acknowledges the pull of kinship in helping others. Humans recognize their own offspring quickly, and Schroeder said, "Research has shown a correlation between degree of relatedness and likelihood of helping others."

There also appears to be an evolutionary root to empathy, Schroeder said. "We may be genetically predisposed to vicariously experience emotion and feel the pain of others. For example, within one day of birth, babies exhibit a sense of empathetic connection with other babies who are crying to express distress."

Another basis for helping is reciprocal altruism, the social norm that if I do something nice for you, you will do something nice for me. There appears to be a genetic drive for such reciprocity.

"Recent evidence suggests that individuals not only reciprocate, but some are inclined to punish those who do not reciprocate, even at some cost to themselves," Schroeder said. "There appears to be an evolutionary basis for punishment in social order, for bringing people back in line who do not reciprocate."

Research has shown that, over time, groups with more cooperators do better than those with more competitors. In many cases, Schroeder observed, "Cooperation proves to be superior to competition in the long run, although competition may do better in the short run. The rule is 'survival of the fittest,' and sometimes being cooperative and pro-social is what being fit really means."

"Nothing in biology makes sense except in the light of evolution."
Evolutionary biologist and Russian Orthodox Christian Theodosius Dobzhansky.

"There are so many ways of thinking about evolution. We're all just trying to sort out the details."
Cindy Sagers, professor of biological sciences, J. William Fulbright College of Arts and Sciences.

John R. Clark

professor of horticulture, Dale Bumpers College of Agricultural, Food and Life Sciences and the Division of Agriculture.

Horticulturalist John R. Clark directs the world's largest blackberry breeding program, as well as breeding projects for a wide variety of fruits and nuts. He and other plant breeders call their work "controlled evolution."

"In our plant breeding, genes come together by design, rather than by birds, insects, wind or other forms of natural gene transfer," Clark said. "Agriculturists also adjust the environment through practices such as irrigation and control of competing weeds."

For hardy, disease-resistant genes, breeders look for "centers of origin" as sources of genes that exist in the wild, such as blackberries in eastern North America. James N. Moore, a Distinguished Professor Emeritus who founded the blackberry-breeding program 45 years ago, crossed early hybrids developed from native U.S. blackberries with other sources, including English thornless hybrids. Subsequent selection resulted in plants with improved berry size and taste, often with thornless canes.

In a process based on the 19th century work of Gregor Mendel, breeders cross-pollinate blackberry plants, collect seeds, grow seedling plants and continue the process until they find the one plant with the desired traits. From first crossing to variety release can take a decade or longer.

Most breeding is done at the Division of Agriculture's Fruit Research Station in Clarksville, Ark., but Clark also oversees testing and breeding of blackberries in Europe, Central and South Africa, Japan and Australia. By learning how genes perform in different environments, blackberry breeders make it possible for growers worldwide to offer nutritious fruit to local markets. This work may also help producers adjust to global climate change and insure a stable food supply.

"We need to be aware of changes in the environment and match genetic resources that are adapted for that environment," Clark said. "We've created a genetic resource here. We have to ask: Is there a way to maximize its useful evolution and to enhance quality of life?"

CINDY SAGERS

professor of biological sciences, J. William Fulbright College of Arts and Sciences.

Biology professor Cindy Sagers has spent much of her career studying a special relationship between ants and tropical plants that seemingly shouldn't exist. In some cases, ants and plants cooperate to form a mutual system where the ants take some of their nutrients from the plants, but also "feed" the plants in return.

"The evolution of this kind of cooperation has been a longstanding puzzle in evolutionary biology," Sagers said. For this kind of relationship, the plants and ants must have co-evolved.

To get to the roots of this puzzle, Sagers and colleagues plan to study ant-plant interactions in different ecosystems throughout Mexico, Central America and South America. They will study the insects and plants to determine their relationships, run genetic studies to determine the species involved and examine the ecosystems where the particular pairings are found to look for co-evolutionary "hot" and "cold" spots.

"If we can understand the ecological factors that contribute to the variation, we can get to the ecological factors that contribute to co-evolution," Sagers said. "We cannot understand the relationship between these ants and plants in isolation."

WILLIAM J. ETGES

professor of biological sciences,
J. William Fulbright College of Arts and Sciences.

Fruit flies have become the "lab rats" of the insect world. They can be found pretty much anywhere there is decaying plant matter. Further, because fruit flies have diversified into thousands of species, reproduce quickly and create many generations in a short time, scientists can use them to study evolution, population genetics and species formation.

Biology professor William J. Etges studies cactophilic *Drosophila*, fruit flies that live in deserts and feed on decaying cacti. While many fruit fly researchers work solely in the laboratory, Etges goes to the desert to study these species in their environment.

Species formation is considered to be a matter of reproductive isolation over time - in other words, two populations become so different that they do not mate or produce viable offspring. Most fruit flies live in mild climates, but a number of species such as *D. mojavensis* have colonized the desert, using fermenting cactus and surviving in high heat and low water conditions. Etges and his colleagues are identifying genes that have helped the fruit flies adapt to these harsh conditions.

"Eventually we want to know about the larger-scale patterns that explain how species are formed," Etges said.

Yanbin Li

professor of biological and agricultural engineering,
College of Engineering and Dale Bumpers College of Agricultural, Food and Life Sciences.

Evolution at its most basic level involves changes in genes, and nowhere is this more apparent than in viruses. Scientists argue about whether or not these tiny strands of RNA constitute living species, but there is little doubt that they evolve. And they evolve extremely rapidly – that's why everyone needs a new flu vaccine every year.

This poses a challenge for biological engineer Yanbin Li, who has worked with a team of scientists to create a biosensor that can rapidly detect the avian flu virus in the field.

"The avian flu virus can change in several days to several weeks," Li said. Eventually, enough mutation could make it difficult to detect the avian flu by standard methods.

Current research is looking for ways to determine which areas of viral RNA change rapidly, which could help scientists determine how best to ensure that mutations don't make it difficult to rapidly detect avian flu.

"Now we can see how they mutate and how under some conditions they are going to mutate," Li said. This will help create better biosensors so that deadly viruses can be detected before birds – or people – have symptoms, thus lowering the risk of an epidemic.

MARY SAVIN

associate professor of crop, soil and environmental sciences,
Dale Bumpers College of Agricultural, Food and Life Sciences.

In the war against infection, humans use antibiotics to vanquish bacteria. And bacteria fight back through evolution – the bacteria that survive the onslaught of antibiotics reproduce and strengthen antibiotic resistance in the remaining bacterial population.

While others ponder the effects of this problem on the human body, professor Mary Savin is examining the effects of antibiotic resistance on stream ecosystems that regularly receive treated effluent from waste management facilities.

She has examined creeks near such facilities and found low levels of antibiotics in the water downstream from the plants.

"The antibiotics are found at low levels, but they are there," she said. "We want to know if these low levels are enough to change resistance levels in bacterial populations."

To do so, the researchers are looking at *E. coli* found upstream and downstream of the point where effluent enters the stream. They are examining the bacterial isolates to check for genes that confer antibiotic resistance, but they also are looking at total bacterial diversity of resistant isolates as well as any changes in diversity from upstream to downstream. They also are looking to see if the antibiotic resistance is something that disappears with time and distance from the effluent source.

"It's possible that the effluent is contributing to antibiotic resistance," Savin said. "Whether it will change its effect on the ecological community is another matter."

"The underlying mechanisms of evolution are part of our everyday lives."
William Etges, professor of biological sciences,
J. William Fulbright College of Arts and Sciences.

Jeff Silberman

assistant professor, biological sciences,
J. William Fulbright College of Arts and Sciences.

Biologist Jeff Silberman spends his time studying the origins and relationships among the "oddballs" of the Tree of Life – single-celled eukaryotes, or organisms that have a nucleus, such as anaerobic organisms, amoebae and flagellates, some of which are parasites. He performs comparative DNA sequence analyses of these extremely basic organisms to help find their particular branch on the Tree of Life.

These "oddballs" and humans have more in common than most people realize – animals, plants, protists and fungi are all eukaryotes, that is, all of these creatures have cells with complex organelles, such as a nucleus and mitochondria. Mitochondria in aerobic organisms power cells by using oxygen to produce energy. They also are involved in the regulation of cell growth and cell death. Mitochondria in anaerobes differ from those in aerobic organisms, and energy production does not seem to be their main function.

"There are lots of things we don't know about the basic functions of cells and their organelles," Silberman said.

Being anaerobic doesn't seem to be a primitive trait. Anaerobic organisms can be found throughout the eukaryotic tree, indicating that it is a an adaptation that has evolved many times independently.

By isolating formerly unexamined anaerobic protists and looking at the independent ways they have formed different types of mitochondria, Silberman hopes to reveal essential commonalities among all eukaryotes, perhaps even clues to the origins of eukaryotes. ■

[small science]

Better Diagnosis

[Science's tiniest materials pack a potential wallop against mankind's most feared diseases.]

By Matt McGowan

The researchers glance furtively at each other and shift in their seats when asked the question: "So, exactly how do these carbon nanotubes detect chemicals in the body?" They hesitate. They smile demurely. They want to accommodate, but, as one of them says in half jest, "the answer to that question might take up the rest of the day."

Their boss is in an anteroom, his office, gathering materials, and the smiles widen when he returns because they know he will take a stab at it. It's not the nanotubes and nanowires and other three-dimensional structures themselves – although they are the critical material – but how they are integrated with thin film transistors – special kinds of transistors that deposit thin film semiconductors on substrates – and electronic communications modules that allow the researchers to build many types of wireless biosensors that detect "biologically derived electronic signals."

[We work at the boundaries of physical, chemical, biological and medical sciences.]

"To do this, the nanostructures are 'functionalized' with conductive linkers such as proteins and peptides that interface with soluble biological targets," says Vijay Varadan, distinguished professor of electrical engineering and director of the Center for Wireless Nano-, Bio- and Info-Tech Sensors and Systems. "The use of vertically aligned nanowire bundles provides a large surface-area density and an excellent base for many sensor surfaces operating in parallel. This creates an increased electrochemically active area for high sensitivity and high signal intensity."

With assistance from the Walton Family Charitable Support Foundation, the university lured Varadan to Arkansas in late 2004 to build a major research center focused on sensor technology with a health-care focus. While at Penn State University, Varadan had established a reputation as pioneer in the field of biosensors to treat neurological disorders, such as Parkinson's disease, Alzheimer's disease and epilepsy.

Today, with additional assistance from the National Science Foundation and the Arkansas Science & Technology Authority, Varadan's biosensor work has expanded into four distinct laboratories that comprise the center. Each lab has it own mission or application, but all rely on the unique properties of nanotubes and nanowires, made of carbon, gold, titanium and conducting polymer, to develop products that will provide better information to health-care professionals, reduce the costs of health care and influence quality of human life.

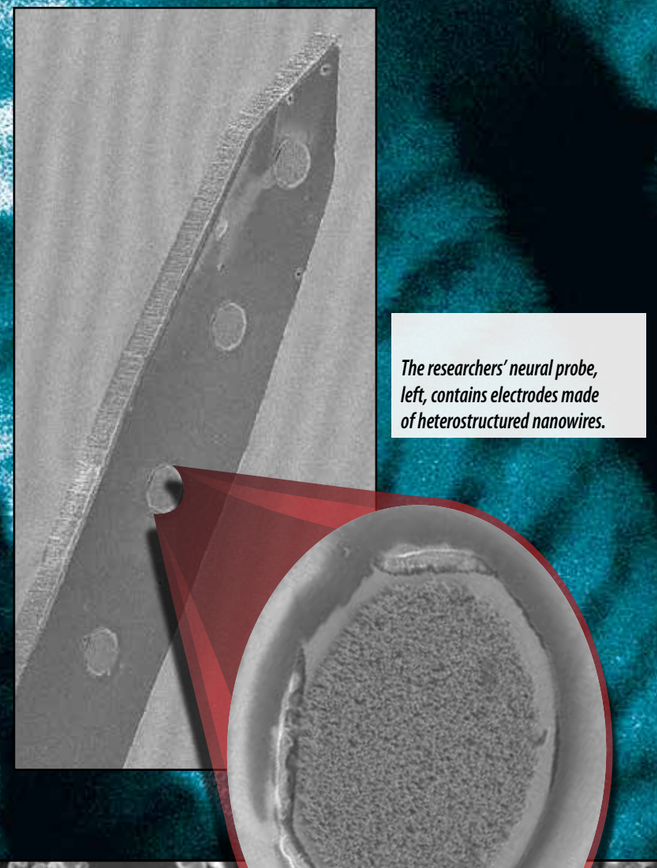
[NANOTUBE POWER]

All this is made possible by the unique characteristics of Varadan's nanotubes and their packaging and interaction with various chemical agents. The nanotubes and wires are hollow, lightweight, chemically inert and mechanically strong. They grow on arrays combined to make chips not unlike those found in computers and other electronic devices. These chips are bio-compatible; the human body will not reject them as a foreign object.

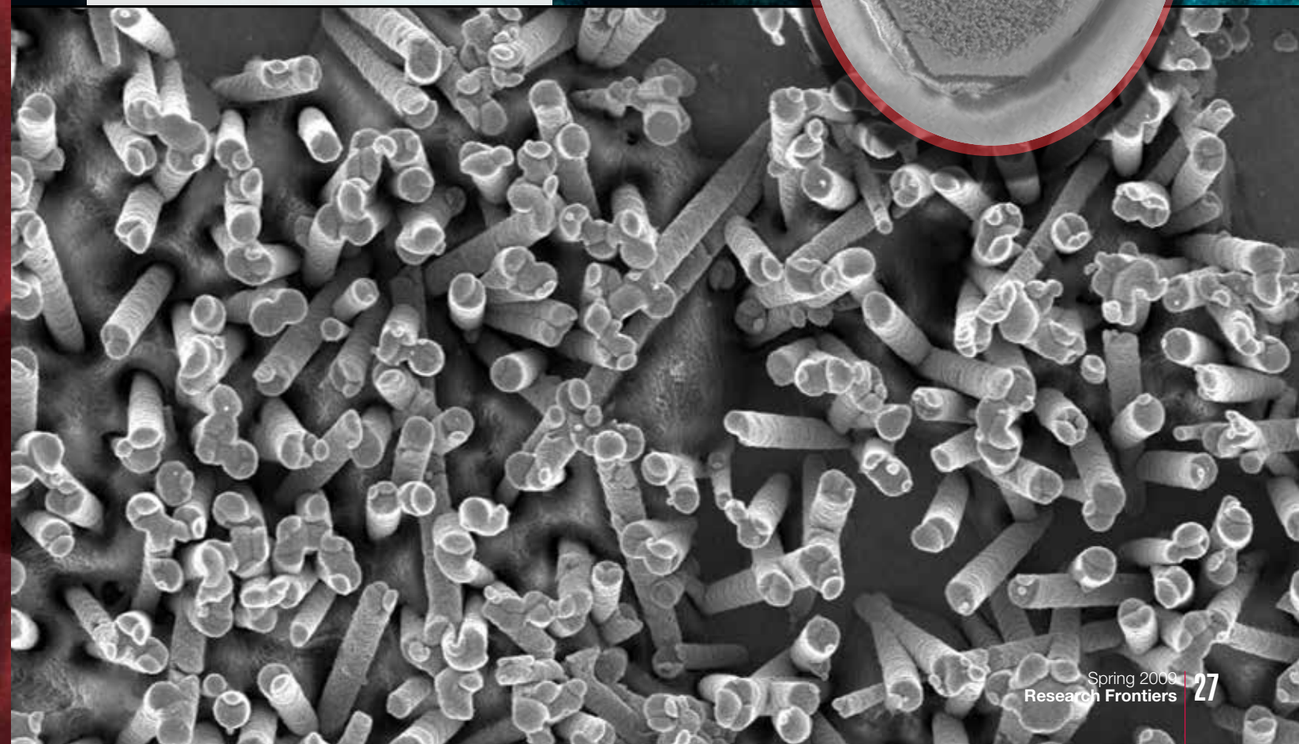
The research started years ago with Varadan's wireless, implantable biosensor that he continues to refine in the center's Brain Wave Lab. Today, the device senses, monitors and actually manipulates chemicals, called neurotransmitters, in the brain. It accomplishes this by recording the loss of dopamine, a major neurotransmitter, and stimulating activity between neurons and neurites, which are immature, developing neurons.

The sensor also works in tandem with other types of sensors to control tremors, the primary physical symptom of Parkinson's, and to direct movement of prosthetic limbs. Specifically, the device communicates with an organic, polymer-based sensor attached to an area of the body in which a tremor occurs. The signal from the sensor implanted in the brain controls and directs the motion of the area of the body on which the exterior sensor is attached.

"If neurites in the brain can be manipulated properly, we can control symptoms of Parkinson's," Varadan says. "We can stop tremors, and patients can live relatively normal lives."



The researchers' neural probe, left, contains electrodes made of heterostructured nanowires.



[DETECTING GLUCOSE]

Another sensor, developed by Jining Xie, research assistant professor, detects and monitors blood-glucose levels in near real time. Working with Varadan, Xie and researchers in the Nanomaterials and Nanotubes Research Laboratory test the sensor, which is made of carbon nanotubes coated with platinum particles between 1 and 5 nanometers in diameter.

The platinum-coated nanotubes exhibit a high sensitivity to detecting glucose, because the platinum nanoparticles create a larger electro-active surface area, Xie said. The larger surface area allows the nanotubes to act as a glucose-oxidase reservoir, which helps create uniform immobilization and high loading of glucose oxides for sensing.

The sensitivity value of the researchers' device is among the best results reported for glucose biosensors. Xie says their goal is to further increase sensitivity. Equally important, the biosensor has a response time of 15 to 30 seconds, which renders it capable of providing glucose screenings close to real time.

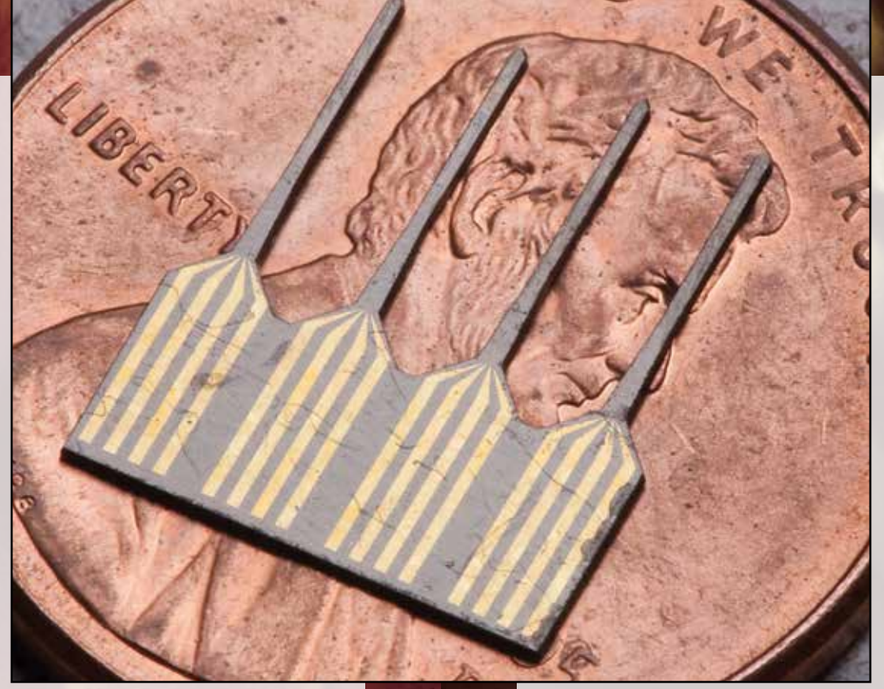
"To manage and control diabetes, patients must continuously monitor blood-glucose levels," Xie says. "So they understand the importance of a device that provides rapid response."

[SMART FABRICS]

Imagine a bed sheet that automatically takes a patient's body temperature and sends the information to a computer at a nursing station, or a shirt that continuously monitors a marathon runner's respiratory rate.

Collaborating with Varadan, researchers in the Organic Electronics and Devices Laboratory have developed two types of sensors – temperature and strain – that can be integrated with so-called "smart fabrics," clothing and even bedding fitted with wireless technology. Such garments monitor vital signs and collect and send data to an information hub in real time. The information can provide immediate detection of physiological abnormalities, which will allow physicians to begin treatment or prevent illness before problems reach an acute stage.

Taeksoo Ji, assistant professor of electrical engineering, and research assistant professor Soyoun Jung work with pentacene, a hydrocarbon molecule, and carbon nanotubes to fabricate the two biosensors. Similar to Xie's experience with platinum, Ji and Jung found that combining pentacene with carbon nanotubes increases sensor sensitivity. An additional benefit is that pentacene, as an organic semiconductor, is efficient and easy to control.



The strain sensor, which monitors respiratory rate, consists of an instrument that measures unknown electrical resistance, and a thin pentacene film that acts as a sensing layer. The system works when physiological strain, such as breathing, creates a mechanical deformation of the sensor, which then affects the electrical current's resistance. The researchers found that the smaller the sensor, the more sensitive it is to current variations.

For the temperature sensor, Ji and Jung use a thin-film transistor, which allows them to observe electrical current in response to temperature change. Most importantly, in low voltage areas, the current displays the highest sensitivity to temperature changes.

Left and above, implantable neural electrodes interface with nuerons to provide clinical applications in neural prosthetics.

"A sensor that can monitor a patient's respiratory rate and body temperature in real time and thus provide point-of-care diagnostics to health-care professionals and greater freedom to patients is huge," Ji says. "We're trying to move diagnostic testing out of the lab and directly to the patient and health-care worker."

Related to this work, a technology company, Shri Lakshmi Nano Technologies, has established a research and development facility in Fayetteville to incorporate an array of flexible nanosensors on bed sheets and pillow cases for physiological monitoring of patients. The company will work closely with Varadan and the other researchers.

[STIMULATING NERVES & MUSCLES]

Researchers in the Innovative Nano- and Bio-Devices and Systems Laboratory are developing a better neural probe, one that has already demonstrated a greater charge-injection and storage capacity – meaning the probe can stimulate nerves and tissues with less damage and sense neural signals with better sensitivity – than all other neural prosthetic devices.

Needle probes are used as neural prostheses to help improve quality of life for patients with severe impairments, such as Parkinson's disease and Tourette syndrome. Other clinical applications include cardiac pacing and defibrillation, restoration of bladder function, electrical stimulation in paralyzed individuals and deep brain stimulation.

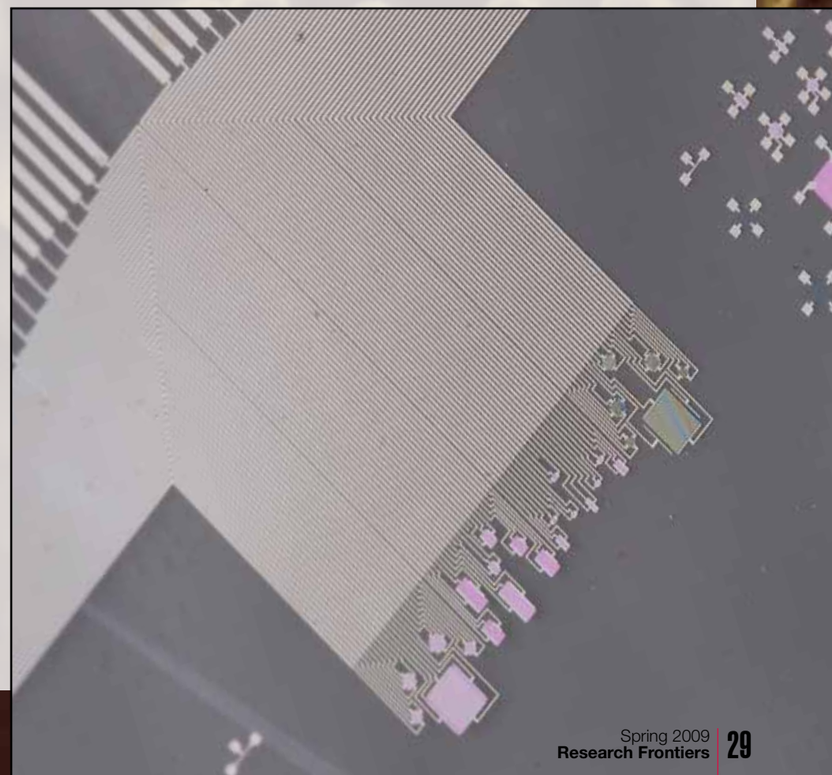
"Our goal is to develop functional systems that can simultaneously stimulate nerves or muscle cells and record physiological changes in the human body," says Hargsoon Yoon, research assistant professor of electrical engineering.

Yoon collaborates with Varadan to develop systems that include nanowire electrodes, wireless communication and a power source for bio-packaging. The wireless network facilitates dynamic adjustments of the system and continuous monitoring of patients during stimulation.

But it is the probe alone that will improve the function and reliability of neural prosthetic devices. Made of a gold core and iridium oxide outer layer nanowires grown vertically on polymer or titanium substrates, Yoon's probe has repeatedly demonstrated charge-storage capacity of more than twice the capacity of probes developed by other major academic research groups. The Arkansas probe has also displayed superior biocompatibility and mechanical strength compared to similar silicon structures.

Because charge-injection capacity is directly related to density of electrical current needed to stimulate nerves and muscle cells, the probe can transfer charge into biological cells and tissues using less voltage – and less battery power – and thus can operate longer with less tissue and cell damage.

"We work at the boundaries of physical, chemical, biological and medical sciences," says Varadan. "Nanomedicine – the application of nanoscience and nanotechnology to medicine – provides revolutionary approaches for the diagnosis, prevention and treatment of fatal diseases. We are happy to be a part of this revolution. There is great excitement in our labs and the hallways that connect them." ■



Right, a wireless sensing and control network will allow for continuous monitoring and dynamic adjustments. The sensors have a small footprint, high flexibility and biocompatibility.

The Odor of Sanctity
Michael Heffernan
Salmon Poetry

In this volume of poetry, creative writing professor Michael Heffernan often mixes the lofty and the wacky. The resulting "mildly irreverent" poems arise from the sometimes-sad circumstances of life.

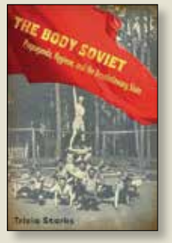
The poems often start at a difficult place and end with a hint of hope.

"Idaho Light" begins with pain. Then, Heffernan writes, "In northern Idaho's voluptuous dreamscape / someone had taken ordinary wheatfields / and shaken them like bedsheets tossed into the light / and brought them down in bundles of swollen gold."

The final poem, "Every Journey Has an End," rose from a scrap of a dream discovered in an old dream journal, an image of a boy on a bicycle. He wondered where the boy on the bicycle was going. He begins with a mysterious encounter between two boys at a shabby house near a cemetery.

Toward the end of the poem come words of wisdom from the grandmother about the need to pray, "especially in mid April, / when the skies often had that look of angel feathers, / and the air smelt of the moment of the Resurrection."

The Odor of Sanctity is Heffernan's eighth book of poetry. His work has earned three fellowships from the National Endowment for the Arts, two Pushcart Prizes and the Porter Prize for Literary Excellence. ■

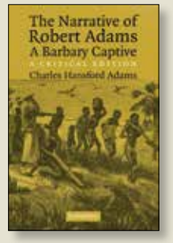


The Body Soviet: Propaganda, Hygiene, and the Revolutionary State
Tricia Starks
University of Wisconsin Press
November, 2008

In *The Body Soviet*, history professor Tricia Starks argues that hygienic thought and health institutions were central to the creation of the new state and its citizens. She places these in international context demonstrating the most pervasive application of early health initiatives in the world.

In 1918 the People's Commissariat of Public Health began a quest to protect the health of all Soviet citizens. Health became more than a political platform or tactical decision. The Soviet people defined the existing world by interpreting political orthodoxy and citizenship in terms of hygiene. Cleanliness developed into a political statement that extended from domestic maintenance to leisure choices and revealed prejudices. Dirt denoted politics; health and cleanliness signified mental acuity, political orthodoxy and modernity.

By examining sources of health care propaganda and medical monitoring institutions of the Soviet state, this book places hygiene and the rhetoric of health at the heart of the revolutionary endeavor. Soviet health programs were more thoroughly applied, more intensely monitored and more radically conceived than anywhere else in the world. ■



The Narrative of Robert Adams A Barbary Captive A Critical Edition
Charles Hansford Adams
Cambridge University Press

Europeans in the 19th century did not believe that Timbuctoo — the fabled city of wealth and learning on the Niger in Mali — could exist. But in 1815, an African American sailor named Robert Adams told powerful leaders in London a fantastic tale of crossing the Sahara as a slave and of his time in Timbuktu.

First published in London in 1816, *The Narrative of Robert Adams* tells of exploration and adventure, one of many tales of Timbuktu circulating.

Charles Adams, professor of English and associate dean of international programs, became interested in these narratives, most of which have been out of print since the 19th century. He found Adams's narrative fascinating and decided to bring it to the attention of modern readers.

By placing the narrative within the context of European exploration and colonialism, Charles Adams illuminates the motives of the storyteller.

So did Robert Adams actually go to Timbuktu, or is this tale another rendition of a legend?

To find answers, Charles Adams studies not only the 1816 account, but also contemporary essays, notes and maps.

"The reader is allowed to know of Robert Adams only what his English handlers chose to show," writes Adams. ■

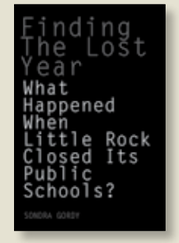
Ruled by Race: Black/White Relations in Arkansas from Slavery to the Present
Grif Stockley
University of Arkansas Press

This book by longtime Arkansas writer Grif Stockley describes the ways that race has been at the center of much of the state's formation and image since its founding.

The subject of race is a passion for Stockley, who was raised in Marianna, Ark. Influenced by the idealism of the Kennedy era but not substantially involved in the Civil Rights movement, Stockley began to question the status quo in earnest after a stint in the Peace Corps overseas.

Stockley began working on the manuscript in 1976. He sought to bring to life the voices of both black and white, those who have both studied and lived the racial experience in Arkansas. The book includes the work of historians and primary source materials, along with stories from authors as diverse as Maya Angelou and E. Lynn Harris.

Topics range from slavery to the Central High Crisis of 1957 to lesser-known events, such as the Elaine Race Massacre of 1919, and the commonplace attitudes found every day in newspaper reports and speeches. Adam Green, author of *Selling the Race: Culture and Community in Black Chicago: 1940-1955*, calls the book "an important and useful contribution to the literature on Arkansas history and to general readers elsewhere." ■



Finding the Lost Year: What Happened When Little Rock Closed its Public Schools?
Sondra Gordy
University of Arkansas Press

During the Little Rock School crisis, the governor of the state closed the public schools for a year. Although much has been written about the crisis itself, little has been published on the lost year when the schools were closed to students, both black and white. *Finding the Lost Year* is the first book to examine how a desegregation crisis turned into a community crisis. In Little Rock in 1958, 3,665 students were locked out of a free public education. Teachers' lives were disrupted. Students were scattered to schools outside the city, some left the state, some joined the military and ot hers took correspondence courses. But fully half the black students went without schooling that year.

Author Sondra Gordy draws on personal interviews with more than 60 former teachers and students, detailing the long-term consequences for students affected by events and circumstances that were out of their control.

Gordy, a history professor at the University of Central Arkansas, also has produced a documentary on the topic, which can be ordered at http://thelostyear.com. ■

Looking Back at the Arkansas Gazette: An Oral History
Edited by Roy Reed
University of Arkansas Press

From its legendary beginning when a printing press was floated up the Arkansas River in 1819, the *Arkansas Gazette* has been inextricably linked with the state's history, reporting on every major Arkansas event until the paper's demise in 1991 after a long, bitter and very public newspaper war. Roy Reed, longtime *Gazette* reporter and professor emeritus of journalism, has compiled and edited more than 100 interviews from former *Gazette* staff members recalling the stories they reported on and the people they worked with from the 1940s to the paper's end. The result is a nostalgic and admiring look back at a publication known for its progressive stance in a conservative Southern state, a newspaper that, after winning two Pulitzers for its rule-of-law stance during the Little Rock Central High Crisis, was considered one of the country's greatest.

The interviews, collected from archives at the David and Barbara Pryor Center for Arkansas Oral and Visual History, provide details on editors and reporters and the daily stories they covered, including Bill Clinton, Razorback sports and more. This work provides an insightful remembrance of a great newspaper. ■

Why Do People Have Different Types of Blood?

Wendy Sisson, clinical instructor of nursing, Eleanor Mann School of Nursing in the College of Education and Health Professions replies:

Your blood type is determined before birth when you inherit DNA from both parents. The inherited genetic information determines which antigens are present on the surface of your red blood cells. An antigen is a protein that is capable of instigating the formation of antibodies. There are four blood types: A, B, AB and O. Tests to determine blood type detect which antigens are present in blood. Red blood cells of the A type have A antigen on them. B red blood cells have B antigen. If both antigens are detected, the blood type is AB. If no antigens are detected, the blood is type O.

Blood groups are also classified by the Rh factor. The Rh factor is another antigen that is present in some people's blood. Blood can either have Rh antigen – Rh positive – or have no Rh antigen – Rh negative.

It is important to know your blood type and Rh status if you must receive a transfusion or if you are pregnant. If you are given a transfusion of blood that contains antigens not already present in your blood, your body will form antibodies to the foreign antigen. The antibodies cause blood to clot and can destroy red blood cells. If an Rh negative mother carries an Rh positive baby and the blood of mother and baby mix, the antibodies formed by the mother can destroy the baby's red blood cells. Rh negative pregnant women are given a medication to prevent this reaction.

The rarest blood type is AB-. Type O- blood is the "universal donor" because transfusions of this type of blood can be given to people with any blood type. Type AB+ is the "universal recipient" because people with this type can receive transfusions of any other type of blood. ■

Photo By: Jim Gathany, CDC

Ouch! Your blood type matters because your body may form antibodies to fight a different type of blood introduced through a transfusion.

What Do Worms Do?

Mary Savin, associate professor of crop, soil and environmental sciences in the Dale Bumpers College of Agricultural, Food and Life Sciences replies:

Worms are ecosystem engineers of the underworld. They are known as a keystone species, because they are extremely important to the ecosystems in which they live. They inhabit the soil and leaf litter found on top of the soil. They consume plant matter, soil, protozoa, fungi and other things that live underground. In addition to "tilling" soil and moving it around, worms also build structure into soil ecosystems. While they facilitate the break down of litter, their activity can increase carbon storage in the long run. They affect the biology, chemistry and physics of their environment.

This strong effect worms have on their environment is not always a desired one. In forested ecosystems of the north, worms died out during the last ice age. Now exotic species introduced by various means, such as unused fishing bait thrown on the ground, are changing the structure and dynamics of these forests.

For good or bad, these underground tubular creatures have a large impact on our environment. ■

Photo by Luis Miguel Bugallo Sánchez, Wikimedia Commons